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and

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BULLETIN OF THE TORREY BOTANICAL CLUB

VOL. 74, NO. 5, PP. 369–373 SEPTEMBER, 1947

LYCOPODIUM COPELANDIANUM, A SUMATRAN CLUBMOSS

RUTH CHEN-YING CHOU AND H. H. BARTLETT*

In describing a distinctive new species of *Lycopodium* from Sumatra in 1929, Copeland[1] inadvertently named it *L. petiolatum*, a binomial long preempted by a species of the Asiatic mainland. He stated that it was without similarity or near affinity to any other species known to him. It is clearly not the same as the older *Lycopodium petiolatum* and is therefore renamed. So clearly distinctive a species may well be named in honor of the eminent pteridologist who first described it, and we are therefore redescribing it as follows.

Lycopodium Copelandianum Chou & Bartlett, nom. nov. *L. petiolatum* Copeland, Univ. Calif. Publ. Bot. **14**: 377. 1929; non Herter, Bot. Jahrb. Beibl. **98**: 36. 1909.

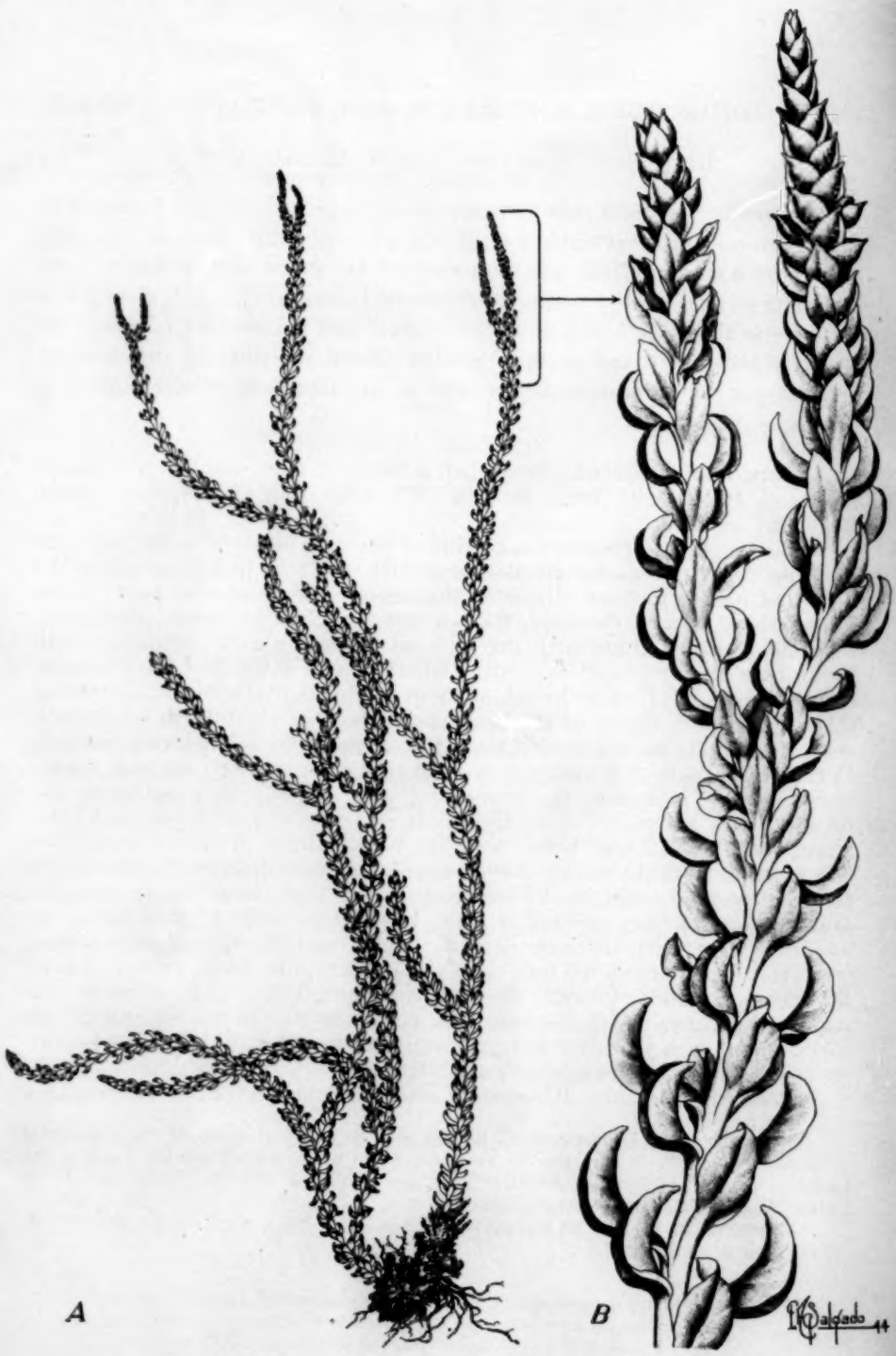
Plants epiphytic, pendulous, rooting at the base only; branches up to 20 cm. long, 3–4 times dichotomously branched, 3–5 mm. diam. including the leaves, of nearly uniform diameter throughout the vegetative part; stems 1 mm. thick toward the base, 0.3–0.5 mm. toward the apex; phyllotaxy 6-farious, subverticillate with three leaves to each whorl alternating with those of the closely placed succeeding whorl; leaves small, fleshy-herbaceous, 2–3 mm. long, 1.2–1.5 mm. broad, ovate in outline if flattened but appearing falcate with both flanks of the blade retroflexed at the midrib, short-petiolate, decurrent; margin entire, slightly undulate; midrib obscure; stomata on the adaxial side of the leaf; epidermal cells elongate, wall sinuous; sporophylls largely in spikes, the lower ones only slightly different from the foliage leaves, subsessile, ovate lanceolate or triangular with rounded base, 2 mm. long, 1.0–1.2 mm. broad near the base, margin undulate, the upper ones distinct from the foliage leaves, aggregated into definite quadrangular, elongate, pointed cones 0.5–1.5 cm. long, 1.5–2.0 mm. diam., sessile, broadly ovate or suborbicular, pointed at apex, 1.2–1.5 mm. long, 1.2 mm. broad toward the base, with distinct, dorsally keeled midrib; sporangium sessile, reniform, 1 mm. broad, 0.5 mm. deep (from margin to sinus); outer cells of the sporangial wall elongate, 80–140 μ long by 20–30 μ wide, more or less regularly arranged with the long axis perpendicular to the margin of the sporangium, with undulate and uniformly thickened wall; spores trihedral, 28–32 μ diam., exospore minutely foveolate.

Dělěng Singkoet, near Bĕrastagi Karoland, Sumatra. (Plant geographers

* Paper from the Department of Botany and Botanical Gardens of the University of Michigan. For the illustrations we are indebted to the Faculty Research Fund of the Rackham School of Graduate Studies. They are published with the assistance of the Lucien Marcus Underwood Memorial Fund.

[1] **Copeland, E. B.** New pteridophytes of Sumatra. Univ. Calif. Publ. Botany **14**: 371–378. 1929. (See p. 377.)

[THE BULLETIN for July–August (74: 279–368) was issued July 16, 1947.]


A
B

and ecologists will be interested in the reference to this locality in a former paper.[2])

The name *Lycopodium Hamiltonii* Spr. var. *petiolata* was proposed by C. B. Clarke[3] for a plant from Khasia. He cited no specimens, which presumably, were numerous, since he says: "Khasia, alt. 4000 ft.; frequent." It would be necessary to see the original material in order to select a specimen to stand as the type. This variety was maintained by Baker[4] for plants from the Himalayas, Kumaon, Moulmain, Lohfaushan, Neilgherries, Concan, and Ceylon. Whatever specimen were to be chosen as a lectotype would clearly have to be one conforming with Clarke's original description, from which we gather that it must have leaves ¼ to ⅓ in. (i.e., 6–8 mm.) long, of thin texture, and laxly scattered. Those of the Sumatran plant here described as *L. Copelandianum* are less than half that long and distinctly fleshy rather than thin. Himalayan *L. Hamiltonii* (not var. *petiolatum*) is described as having the leaves of the same length as those of the variety, although thick, and both species and variety have scattered, not subverticillate leaves.

Herter[5] in his study of Lycopodium in 1909, did not cite Clarke's original publication but raised the variety to specific rank on the basis of Baker's later publication, placing it with *L. Poisonii* in the incorrectly named Series "Poisonia" under subgenus *Urostachys*. Herter did not follow conventional procedure in making the new binomial, since he attributed it to Baker "pro var." in the systematic enumeration (l.c., p. 36) and did not cite the name-bearing synonym. It might therefore be argued that the binomial was not definitely established by him. In the index to his paper he gave the authority as "Bak. et Hert." The binomial has been taken up by other authors, however, and should be retained as *Lycopodium petiolatum* (C. B. Clarke) Herter, to avoid confusion.

In his formal enumeration of species Herter gives the distribution of *Lycopodium petiolatum* as the tropical Himalayan part of the Monsoon

[2] **Bartlett, H. H.** The Batak Lands of North Sumatra, from the standpoint of recent American botanical collections. Univ. Philipp. Nat. Appl. Sci. Bull. **4**: 211–323, *maps 1–2*. 1935.

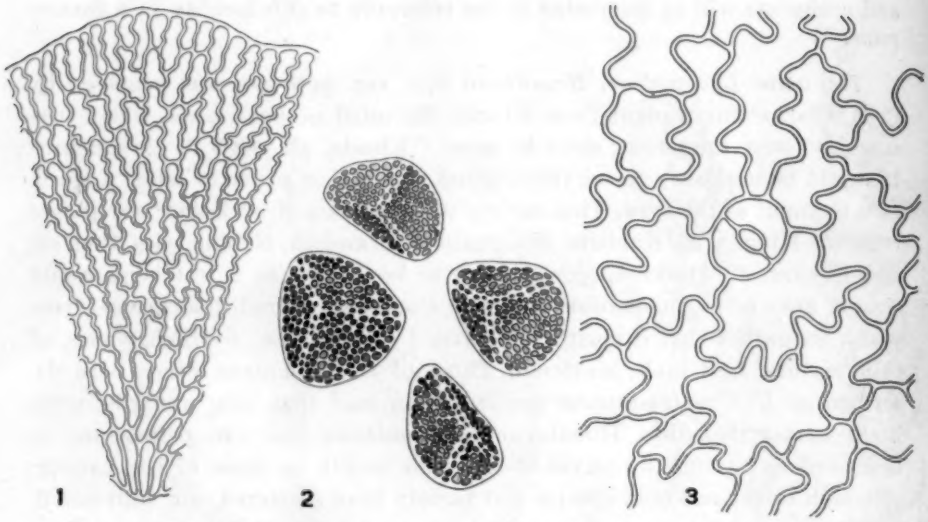
[3] **Clarke, Charles Baron.** A review of the ferns of northern India. Trans. Linn. Soc. II. **1**: 425–611. 1880.

[4] **Baker, J. G.** Handbook of the fern-allies. London, 1887. (See p. 9.)

[5] **Herter, W.** Beiträge zur Kenntnis der Gattung *Lycopodium*. Studien über die Untergattung *Urostachys*. Bot. Jahrb. Beibl. **98**: 1–56. *f. 1–4. 4 tables*. 1909.

Explanation of figures A and B

Lycopodium Copelandianum. FIG. A. Habit of cotype in Herb. Univ. Mich., *Bartlett 6575*, showing subverticillate arrangement of lower leaves. ×0.65. FIG. B. Portion of branch showing gradual transition from vegetative leaves to sporophylls, and terminal strobili. (Sporangia are found on some leaves well below the specialized sporophylls of the strobilus.) ×4.



FIGS. 1–3. *Lycopodium Copelandianum*. FIG. 1. Portion of sporangial wall. ×95. FIG. 2. Spores. ×405. FIG. 3. Epidermal cells of upper (adaxial) side of leaf with stomata. ×225.

region only, but elsewhere (in the discussion of geographic distribution) he ascribes it also to Japan. The only species which he considers related to it he describes from Japan, as *L. Poisonii*.

Nessel[6] in his monograph of *Lycopodium* of 1939 (as stupidly muddled a work as often plagues the botanist) maintains "*Urostachys petiolatus*

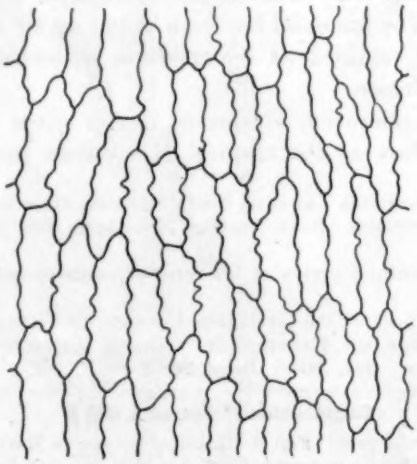


FIG. 4. Epidermal cells of lower side of leaf of *Lycopodium Copelandianum*. ×80.

[6] **Nessel, H.** Die Bärlappgewächse (Lycopodiaceae). Jena, 1939.

(Bak.) Hert., non C. B. Clarke'' as a species and also keeps it as a variety under *Lycopodium Hamiltonii*, separating the two by some 270 other species, varieties, and forms in the synopsis. As a *Urostachys* he gives the wrong authority for the binomial, which, as far as there is any evidence, should be *U. petiolatus* (C. B. Clarke) Nessel. Whatever may be newly chosen as the actual (but originally uncited) type of Clarke's variety must also be the type of all the names created by Herter's and Nessel's inept juggling of Clarke's varietal name. Baker established no variety of his own, but merely maintained Clarke's. The same type can serve for only one of the two presumably distantly related plants which Nessel recognizes, for distant they must be if Nessel's classification represents natural grouping at all.

At any rate the binomial *Lycopodium petiolatum* (C. B. Clarke) Herter had been used, even though with the wrong authority, and had been accepted by other authors, prior to the publication of the homonym *L. petiolatum* Copeland. It becomes necessary, therefore, to give the latter a new name. Copeland's species was based upon a type specimen from Sumatra which does not correspond with the Indian plant known as *Lycopodium Hamiltonii* var. *petiolatum* or other names derived from that. Advantage is taken of the necessity for renaming Copeland's species to present an emended description, together with excellent drawings prepared by Mr. Eduardo Salgado from a cotype in the Herbarium of the University of Michigan (figs. A–B, 1–4).

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 74, NO. 5, PP. 374–377 SEPTEMBER, 1947

LYGODIUM FLEXUOSUM VAR. ACCIDENS, A NEW CLIMBING FERN FROM KWEICHOW PROVINCE, CHINA

RUTH CHEN-YING CHOU*

In the Gray Herbarium of Harvard University there is a single not too complete specimen of a fern which differs from plants considered to be *Lygodium flexuosum* (L.) Sw. chiefly in having the rachis nodose-articulate at the base of the petiolules. The characteristic is a definite and distinctive one, and it is to be presumed that the articulation provides for abscission of the leaflets, which are probably deciduous. It is questionable, however, whether the feature in question is one that should be used as a basis for specific separation of the plant. Nothing is known about the distribution of the type with articulately nodose rachis, of its constancy, or whether or not sufficient material would show other correlated distinctions to justify the description of a new species.

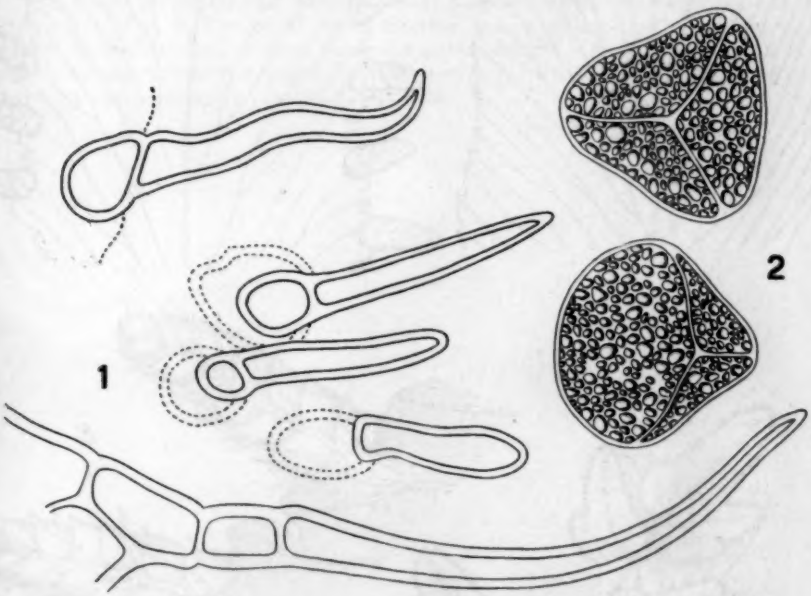
I have made a key to Chinese *Lygodia* on the basis of spore characteristics, and have found that the new variety here described from too young material may eventually be found to have additional characteristics. For the present, however, the matter is not certain and the type specimen is not so ample as one might wish.

Consequently, believing that the attention of botanists should be called to the existence of such a distinctive thing, but not wishing to establish a species on the basis of insufficient material, I am describing the peculiar plant as *Lygodium flexuosum* var. *accidens*. I am of the opinion, however, that some time, when more and complete specimens have been observed, it may be desirable to elevate the variety to specific rank. For this reason I give a detailed description of the type specimen, so that its identity may be clear to those who in the future may not have the advantage of interpreting it by examination of the type specimen.

LYGODIUM FLEXUOSUM (L.) Sw. var. **accidens** Chou, var. nov. Axes (primarius et secondarii) straminei, nitidi, inferne subglabri vel pilis deciduis sparsim praediti, superne plus minusve pubescentes, marginibus acute costatis vel subalatis. Brachyrrhachis dichotomialis 5 vel 6 cm. longa, folia dua quasiopposita pinnate composita et ad dichotomiam gemmam dormientem terminatem pilosam ferens; pilis gemmae stramineis 0.5–1.0 mm. longis, 24–40 μ diam., subcylindricis gradatim ad apicem rectum vel curvatum angustatis ex cellulis 1 vel 2 basalibus et 2–4 ulterioribus constantibus;

* Paper from the Department of Botany and Botanical Gardens of the University of Michigan.

foliis quasioppositis 20 cm. longis vel longioribus (petiolo incluso) pinnas 2–5 infra pinnam terminalem ferentibus; petiolo 3.5–4.0 cm. longo, plerumque bis longiore quam parte rhachios inter pinnam primam et secundam; rhachi nodose articulata ad petiolulorum basin; pinnis petiolulatis, basalibus palmate 3- vel 5-lobatis, lobo mediano quam lateralibus longiore, 4–6 cm. longo, 1.5–2.0 cm. lato (spicis marginalibus sporangialibus inclusis) basi valde cordato vel hastate auriculato; pinnis superioribus, 1- vel 2-lobis, basi sagittatis vel paululum cordatis, utrinque inconspicue pilosis, pilis brevibus, apiculatis, 1- vel pauci-cellulis cum aliis intermixtis clavatis glandularibus unicellulis; venulis tri- vel quadrifurcatis, utrinque aequaliter prominenti-



FIGS. 1, 2. *Lygodium flexuosum* var. *accidens*. FIG. 1. Hairs from the epidermis. FIG. 2. Spores. Both figures × 605.

bus; plus minusve pubescentibus; margine pinnarum fertilium spicis sporangialibus densis monostichis ornata; margine pinnarum sterilium serrata, venulis ad apices dentium desinentibus; spicis nullis infra sinum; indusiis dense imbricatis sporangia ferruginea vel aurantiaca tegentibus; sporis pallide griseis, trihedricis, 60–85 μ diam. (saepissime 70–80 μ).

Typum legit Y. Tsiang, sub num. *7326*, 7 Oct. 1930 in silvis sparsis ad altitudinem 200 m. prope Chowshang in praefectura Changfeng, provincia Kweichow, Sina.

The type material was identified by R. C. Ching as *L. flexuosum*, to which it is likely of nearest affinity and under which I tentatively place it as a variety. However, its nodose-articulated rachis and petiolules (possibly with spore characteristics which are uncertain because of the immaturity of the specimen) justify giving it a name.

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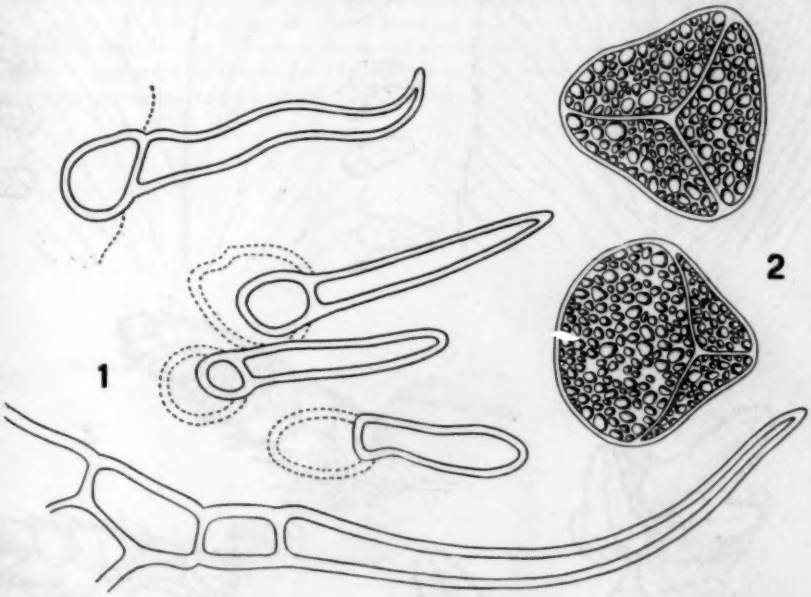

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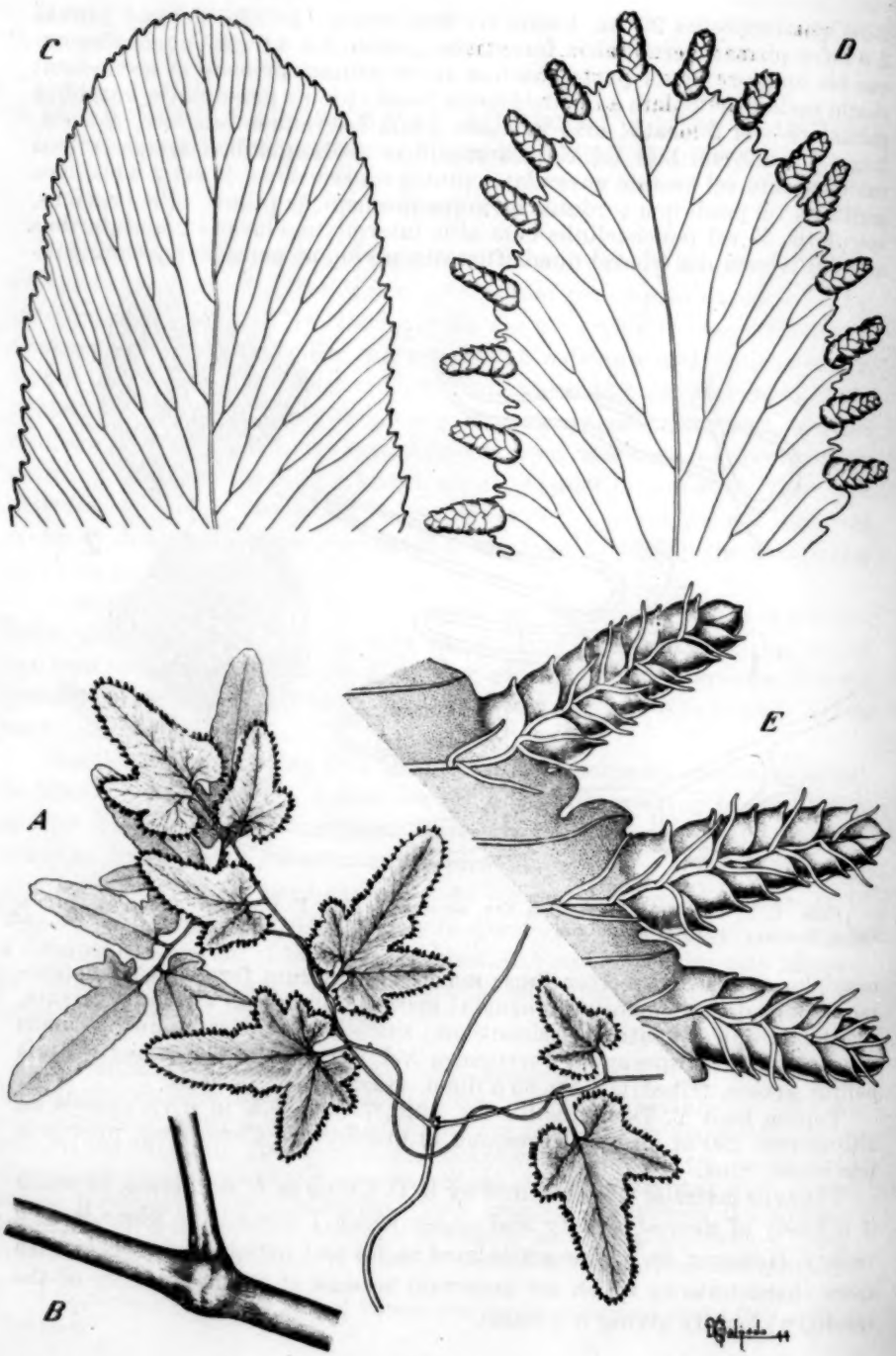
C
D
A
E
B

Taking into account the unsatisfactorily ascertained characteristics of the spores, this new variety would show affinity to *L. japonicum* (Thunb.) Sw. Thus one may surmise that if it is really a specific entity, its systematic position is intermediate between *L. japonicum* and *L. flexuosum*.

DEPARTMENT OF BOTANY, UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

Explanation of figures A—E

Lygodium flexuosum var. *accidens*. FIG. A. Habit of the type specimen, *Y. Tsiang 7326*. × 0.4. FIG. B. Portion of rachis showing nodose articulation. × 5. FIG. C. Apical portion of sterile pinnule showing veins and serrate margin. × 3. FIG. D. Portion of fertile pinnule showing sporangial spikes (ventral view). × 3. FIG. E. Sporangial spikes enlarged showing presence of hairs (ventral side). × 13.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 74, NO. 5, PP. 378–382 SEPTEMBER, 1947

SUPPLEMENTARY NOTES ON AMERICAN MENISPERMACEAE—IV

B. A. KRUKOFF AND H. N. MOLDENKE

Extensive collections of the Menispermaceae, largely from Amazonian Brazil, have recently become available to us. The collections examined extend our knowledge of certain species previously known to us from incomplete material; extensions of ranges are noted for a considerable number of species, and one species, *Abuta Soukupi* Moldenke, is described as new. No changes in nomenclature are necessitated.

The species are arranged in the same order and the place of deposit of specimens is shown by the same abbreviations as in our previous papers (1, 2, 3, 4, 5). The following new abbreviations are used:

DS: Dudley Herbarium, Stanford University, California.

IAN: Instituto Agronômico do Norte, Pará, Brazil.

MPU: Institut Botanique de l'Université de Montpellier, France.

CHONDODENDRON Ruiz & Pavon

1. CHONDODENDRON MICROPHYLLUM (Eichl.) Moldenke. Additional specimens examined: BRAZIL—BAHIA: *Curran 541* (G); basin of Rio Pardo, *Froes 12686, 12689a;* basin of Rio Santa Ana, *Froes 12701.*

2. CHONDODENDRON PLATIPHYLLUM (A. St. Hil.) Miers. Additional specimens examined: *Esc. Sup. Agr. & Vet. s.n.* (*Kr. Herb. 17734*).

3. CHONDODENDRON TOMENTOSUM Ruiz & Pav. Additional specimens examined: ECUADOR—ORIENTE: Rio Yatape Pacayaco, alt. ± 580 met., *Gill I* (DC). PERU—SAN MARTIN: San José de Ciza, *Massey s.n.*

5. CHONDODENDRON LIMACIIFOLIUM (Diels) Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of the upper Jurua, munic. Eirunepé, *Froes 21700, ? 21709, 21710, 21711, 21776, ? 21785, ? 21794.*

The first record of the species from the basin of Rio Jurua.

7. CHONDODENDRON TOXICOFERUM (Wedd.) Krukoff & Moldenke. Additional specimens examined: COLOMBIA—AMAZONAS: near Leticia, *Grassl 10076, Hermann 11309* (W.). PUTAMAYO: Rio San Miguel ó Sucumbios, *Schultes 3522.* PERU—IQUITOS: *Rosengarten I.* BRAZIL—AMAZONAS: basin of the upper Jurua, munic. Eirunepé, *Froes ? 21734, ? 21756, ? 21763, ? 21770, 21802a, 21836.*

The first record of the species from Colombia. The vernacular name "sa-pĕ-pa" for the species is recorded by Schultes, who also notes on his label that "the wood of stem crushed to make curare poison."

SCIADOTENIA Miers

2. SCIADOTENIA PARAËNSIS (Eichl.) Diels. Additional specimens examined: BRAZIL—PARÁ: near Belém, *Murça Pires & Black 531.*

9. SCIADOTENIA CAYENNENSIS Benth. Additional specimens examined: BRAZIL—PARÁ: *collector undesig. s.n.* (MPU).

10. SCIADOTENIA BRACHYPODA Diels. Additional specimens examined: BRAZIL—AMAZONAS: basin of the upper Jurua, munic. Eirunepé, Mucambinho Revalisa, *Froes 21834*.

12. SCIADOTENIA SPRUCEI Diels. Additional specimens examined: BRAZIL—AMAZONAS: *Ducke 854*.

13. SCIADOTENIA TOXIFERA Krukoff & Smith. Additional specimens examined: PERU—IQUITOS: Huyabamba, *Murça Pires & Black 870;* near Iquitos, *Rosengarten 2*.

The species has been known to date from two sterile collections from Ecuador. The specimen is the first one known with staminate inflorescences. A description of the flowers follows: staminate flowers; sepals about 14, very thick-textured, leathery, firm, ovate, convex and densely appressed-strigose on the outer surface, concave and smooth on the inner surface, acute at apex, closely imbricate in 3 or more series, the outermost minute, about 0.6 mm. long and 0.5 mm. wide, the innermost ca. 2 mm. long and 1.7 mm. wide, the remainder intermediate in size; petals 6, broadly spatulate, very fleshy, erect, firm, ca. 1 mm. long and 0.8 mm. wide, rounded at apex and at the apex of the 0.2 mm.-long claw, thickened into 2 parallel, very fleshy, median, erect ridges or humps extending from the apex of the claw to beyond halfway up to the apex of the expanded portion of the petal, so closely adjacent as to practically touch, all the petals appressed-pilose on the back and ciliate on the margins; stamens 6, connate at the base, the connate portion 0.6–0.7 mm. long, glabrous, terete, the free portions ca. 0.8 mm. long in all, glabrous; anthers lateral, light colored, horizontally dehiscent, ca. 0.6 mm. wide.

ANOMOSPERMUM Miers

1. ANOMOSPERMUM SCHOMBURGKII Miers. Additional specimens examined: BRAZIL—PARÁ: near Santarem, *Ducke 16378* (PG). VENEZUELA—BOLIVAR: *Steyermark 59220* (F, N), *60623* (F, N), *60565* (F, N).

The first record of the species from Venezuela.

3. ANOMOSPERMUM RETICULATUM (Mart.) Eichl. Additional specimens examined: COLOMBIA—AMAZONAS: Loretoyaco, *Black & Schultes 46–161*. BRAZIL—AMAZONAS: basin of the upper Jurua, munic. Eirunepé, Adelia, *Froes 21822a*. PARÁ: basin of Rio Jamundá, *Ducke 11733* (PG).

The first record of the species from Colombia and from the basins of the rivers Jamundá and Jurua in Brazil.

6. ANOMOSPERMUM CHLORANTHUM Diels. Additional specimens examined: ECUADOR—AZUAY: "in region of Sanaguin, in rich rain forest jungle," *? Steyermark 52749* (F, N).

TELITOXICUM Moldenke

1. TELITOXICUM KRUKOVII Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of the upper Jurua, munic. Eirunupé, *Froes 21789*.

The first record of the species from the basin of Rio Jurua.

5. TELITOXICUM DUCKEI (Diels) Moldenke. Additional specimens examined: BRAZIL—BAHIA: basin of Rio Santa Ana, munic. Ilheos, *Froes 12718*.

This is the first record of the genus from the State of Bahia.

ABUTA Barrère

1. ABUTA MACROCARPA Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of the upper Jurua, *Froes 21768*.

The first record of the species from the basin of Rio Jurua.

2. ABUTA OBOVATA Diels. Additional specimens examined: VENEZUELA—BOLIVAR: between Santa Teresita de Kavanayen and Rio Pacairao (tributory of Rio Mouak), *Steyermark 60395* (F, N).

The first record of the species from Venezuela.

3. ABUTA BULLATA Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of the upper Jurua, munic. Eirunepé, *Froes 21699, 21755, 21796*.

The first record of the species from the basin of Rio Jurua.

9. ABUTA COLOMBIANA Moldenke. Additional specimens examined: COLOMBIA—VALLE DEL CAUCA: *Cuatrecasas 14028*.

The first record of the species from Valle del Cauca.

11. ABUTA GRANDIFOLIA (Mart.) Sandw. Additional specimens examined: COLOMBIA—AMAZONAS: basin of Rio Putumayo, *Schultes 3740*. BRAZIL—AMAZONAS: basin of Rio Solimoes, *Ducke 360* (A).

13. ABUTA SELLOANA Eichl. Additional specimens examined: BRAZIL—MINAS GERAES: *Esc. Sup. Agr. & Vet. 1632, 3532*.

14. ABUTA RUFESCENS Aubl. Additional specimens examined: VENEZUELA—MERIDA: along Rio Onia, near Bolero, *Steyermark 56700* (F, N). BRAZIL—AMAZONAS: basin of the upper Jurua, municipality Eirunepé, *Froes 21708, 21754, 21758, 21764*. PARÁ: near Belem, *Murça Pires & Black 661*. MINAS GERAES: *Esc. Sup. Agr. & Vet. 1630*.

The first record of the species from Venezuela and from the basin of Rio Jurua in Brazil.

16. ABUTA GRISEBACHII Triana & Planch. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Negro ("Jauaraté"), *Froes 21277* (IAN); near Parintins, *Murça Pires & Black 1149*.

17. ABUTA CANDOLLEI Triana & Planch. Additional specimens xamined: BRAZIL—PARÁ: Belterra, *Baldwin Jr. 2752* (N, W).

18. ABUTA SPLENDIDA Krukoff & Moldenke. Additional specimens examined: VENEZUELA—MERIDA: along Rio Onia, near Bolero, *? Steyermark 56701* (F, N). COLOMBIA—PUTUMAYO: Rio San Miguel o Sucumbios, Conejo y los alredadores, *Schultes 3525*.

The first record of the species from Colombia and Venezuela. The vernacular name "sa-pĕ-pa" for the species is recorded by Schultes, who also notes on his label that the plant is used in preparation of curare.

22. **Abuta Soukupi** Moldenke, sp. nov. Planta lignosa; ramis gracilibus longitudinaliter striatis carinatisque glabris; foliis alternis, supra cicatricem ferruginoso-tomentosis; petiolis gracilibus 7–12 mm. longis non incrassatis obscure pilosulis glabrescentibus; laminis firme membranceis anguste ellipticis 8–15 cm. longis, 2–4 cm. latis, acuminatis integris, ad basin cuneatis, utrinque glaberrimis pernitidisque; venis secundariis 2; venis venulisque utrinque argute prominulis; inflorescentiis ♂ anguste racemosis foliosis; floribus subumbellatis.

Woody plant; branches slender, longitudinally striate and sharply ridged for 1–2 cm. below each leaf scar (at least at and near the tips of the

branches), glabrous except just above each leaf-scar where there is a short longitudinal band of dense ferruginous-tomentose hair; leaves alternate; petioles slender, 7–12 mm. long, very obscurely scattered-pilosulous, becoming glabrous, not enlarged at base nor apex, flat on the upper (axial) surface; blades firmly membranous, narrow-elliptic, 8–15 cm. long, 2–4 cm. wide, acuminate at apex, entire, cuneate at base, glabrous and very shiny on both surfaces; midrib slender, sharply prominulous on both surfaces; secondaries one pair, issuing at the very base of the leaf, exactly similar to the midrib in texture and prominence on both surfaces, extending to 2 or 3 cm. from the apex and there ending in many loops; tertiaries very numerous, extending at almost right angles from the midrib and secondaries and connecting them, they and the veinlet-reticulation uniformly slender and sharply prominulous on both surfaces, only slightly less elevated than the secondaries and midrib; staminate inflorescence axillary or supra-axillary, toward the tips of the branches, 1–3 per axil, 3.5–10 cm. long, regularly 1.5–2 cm. wide throughout, racemose, the longer ones often bearing one or more leaves which are similar to the stem-leaves in all respects except only to 8.5 cm. long and 2 cm. wide; rachis slender, continuous and uniform in thickness from base to apex of raceme, straight, firm, more or less short-pilose with ferruginous or yellowish hairs, especially toward the base, glabrescent in age, with dense tufts of short hair at the base of each side-branch; side branches of the raceme very slender, firm, straight, 5–8 mm. long, widely divergent, slightly pilosulous or glabrescent, bearing at their apex a dense many-flowered umbelloid cluster of flowers; pedicels slender, 1–3 mm. long; flowers wide open in anthesis, with the anthers very conspicuous: the 3 outer sepals membranous, light, wide-spreading or reflexed, concave (if at all) on the outer face, about 1 mm. long, elliptic, acute at apex, glabrous; the 3 inner sepals membranous, light, translucent at the reflexed subhyaline margins and apex, obovate-elliptic, about 1.7 mm. long and 1.3 mm. wide, glabrous; the 6 stamens in two groups of 3 each, each group widespreading from the center, about 1 mm. long; filaments dark, much more slender than the anthers; anthers yellow.

The type of this species was collected by Jaroslaw Soukup, S.S. (*1466*), at Lima, Peru, in 1941, and is *1124877* in the herbarium of the Chicago Natural History Museum. The species is apparently closely related to *A. grandifolia* (Mart.) Sandw. which differs in the following characters: leaves much larger and heavier; midrib and secondaries stouter, not as sharp on either surface; tertiaries and veinlet reticulation not prominulent on either surface, at least, not sharply so; petioles with a usually well-developed pulvinus at the apex and base; branches round in cross-section and completely glabrous throughout, without bands of tomentose hair at the leaf-scars; inflorescence completely glabrous throughout, without tufts of hair, very irregular in size and shape, usually in large clusters in the leaf-axils, very loose and open; flowers borne singly or in pairs on pedicels of very irregular length, not at all umbellate-clustered; the 3 outer sepals thick-textured, opaque, lanceolate, concave on the inner face, convex on the outer face, about 0.8 mm. long and 0.4 mm. wide, obtuse at apex, microscopically puberulent; 3 inner sepals thick-textured, opaque, elliptic-suborbicular, concave on the inner face, convex on the outer face, about 1 mm. long and 0.8 mm. wide, rounded or obtuse at apex, microscopically puberulent; the

6 stamens central, erect, parallel, about 0.6 mm. long, dark, their filaments thick, not conspicuously thinner than the anthers.

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A COLLECTION OF MARINE ALGAE FROM BRAZIL

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While stationed with various Naval Air Facilities in Brazil during parts of 1944 and 1945, the senior author had an opportunity of collecting a limited number of marine algae from this South American republic. Of course, other activities in the line of duty as well as lack of certain facilities prevented any extensive study. But, on the other hand, having facilities of the Navy for travel afforded certain advantages, at least for making observations. Practically the whole coast line of Brazil, extending over a distance of some 3,700 miles and embracing 36 degrees of latitude, was viewed either from high-flying planes, or low, more slowly-moving blimps. Also, the shore was observed at close range from the ground at various places, such as São Luiz, Fortaleza, Natal, Recife, Maceio, Bahia, Rio de Janeiro, and Santos.

It was obvious from these observations that much of the shore line of northern Brazil as far south as Natal must be mostly barren of littoral algae because of the lack of suitable habitats. For one thing, the gigantic Amazon pours into the ocean a tremendous volume of muddy fresh water, especially during flood season, which spreads out on both sides of its estuary for hundreds of miles along the coast, creating muddy shores and extensive fresh or brackish marshy areas. Secondly, other portions not affected by fresh water apparently lack exposed reefs or rocky shore-lines but consist mostly of long stretches of barren sandy or muddy beaches, which are unsuitable habitats for attachment of algae.

These conclusions on the scarcity of algal habitats on the coast of northern Brazil are supported by the paucity of records in the literature on littoral algae from this area. In a synopsis of the records of marine algae from Brazil (Taylor 1930), only two species are listed as having come from north of Fortaleza, located about 750 miles south of the Amazon estuary. Near Fortaleza, however, is a rocky cape (Mucuripe) which has apparently furnished some algae (36 spp.), but from there to Natal the coast is again a barren, sandy beach.

The approximately 3,700 miles of Brazilian shore-line may be roughly divided into three distinct regions. The northernmost 1,350 miles consist mostly of sandy or muddy beaches and the wide Amazon estuary. This area is apparently almost devoid of littoral algae. The middle portion of some 500 miles has an offshore reef consisting of consolidated sandstone which furnishes ideal habitats for many algae. The extensive southern coast of about 1,850 miles has several stretches of rocky shores, which also offer favor-

able substrata for attached algae. It is mainly from this southern part of the coast that most of the material has come upon which our previous knowledge of the marine algae of Brazil is based.

The sandstone reef which skirts the middle portion of the coast of Brazil, extends, with some interruptions, from approximately the northern boundary of the state of Pernambuco through the vicinity of Maceio to some distance north of Aracaju. The reef varies in its distance from shore, extent to which it has been eroded, and exposure above the sea. Large portions of it are exposed at low water and in many places it is even exposed at high tide (fig. 1). In several places outside of certain estuaries where it acts as a breakwater this reef has made harbors possible. This is the situation especially at Recife, which has received its name from this reef.

FIG. 1. Portion of sandstone reef south of Recife, Pernambuco, Brazil.

The reef itself is not only an excellent habitat for algae but also the channel or lagoon between it and the beach. From the standpoint of algal habitats it reaches its best development just south of Recife. The majority of algae listed below were collected at this locality. Collecting was done during the first four months of 1945, but mainly during February and March. No doubt other species might have been obtained from the nearby estuaries and mangrove swamps, but because of the danger of infection from the heavily polluted water no collecting was attempted in such places.

While no special study was made of distribution of species in relation to habitats, some impressions regarding this were gathered from general observations while collecting. The habitats may be generally classified into (1) those pertaining to the reef itself, and (2) those associated with the reef.

Because of erosion by wave action the reef varies greatly in relief, exposure to air, and wave action. The surface is in general uneven and, in many places broken or deeply fissured (fig. 1). The ocean side is exposed to severe wave action while the channel side is more or less protected. All of these variations offer a variety of habitats for algal attachment and growth.

Growing on the upper ledges of the steep outside parts of the reef and hence subjected to constant pounding by waves as they break over the reef are three species of *Gracilaria* (*G. ferox, G. cornea, G. ornata*), *Bryothamnion Seaforthii, Digenea simplex, Vidalia obtusiloba,* and *Sargassum polyceratium.* Ledges in deeper water—three or more feet below low tide level—are frequented by three species of relatively large brown algae, *Spathoglossum Schröderii, Dictyopteris Justii,* and *Zonaria zonalis.* Others associated with these are *Halimeda discoidea* and *Liagora ceranoides.*

Where the reef does not rise abruptly but slopes gradually outward and wave action is less severe, such species as *Gracilaria cervicornis, Botryocladia Uvaria,* and *Laurencia scoparia* grow abundantly. Below this are reddish-brown mats of *Bostrychia Binderi* and *Hypnea spinella* interwoven with filaments of *Lophosiphonia obscura.*

Over the top of the reef where it is exposed between waves, especially at low tide, is a dense, dull-green carpet of various species of which the following are typical: *Laurencia papillosa, L. obtusa, Acanthophora spicifera,* and *Amansia multifida,* usually interwoven with a growth of the wiry *Gelidium rigidum.*

Attached to the walls of the transverse and diagonal fissures in the reef and hence protected from strong light and desiccation at low tide are *Anadyomene stellata, Valonia ventricosa, Dictyosphaeria cavernosa,* and *Cladophora membranacea.*

On the inside walls exposed between waves at low tide is a virtual paradise for the genus *Caulerpa.* Here the following five species grow luxuriantly: *C. crassifolia* f. *mexicana, C. Lycopodium, C. prolifera, C. sertularioides,* and *C. racemosa* var. *uvifera.*

The protected areas in the lagoon between the reef and the sandy beach support a variety of species. Here the bottom is composed of rock or silt and the plants are protected from strong waves. The nature of the bottom largely determines the quality of the flora. Here are found beds of *Ulva; U. fasciata* being the most abundant and *U. Lactuca* var. *rigida* less so. The former extends in places up on the walls of the reef. Two species of *Padina* (*P. gymnospora* and *P. Vickersiae*) grow in beds of silt. There are also small, scattered patches of *Dictyota cervicornis* and *Dilophus alternans.* Growing in shallow rock pools just below low tide level is an abundance of a unique rugged form of *Hypnea musciformis* and frequently beds of *Sargassum platycarpum.* Similar habitats are also frequented by *Gracilaria cornea* and

G. cylindrica, which are fed upon by herds of sea hares which, when disturbed, interfere with collecting by discharging a deep purplish exudate. Small green patches of *Caulerpa pusilla* were found in silt where plants are protected by the reef wall. *Halymenia Floresia* and *H. floridana* together with *Nemalion Schrammii* grew attached to a rock bottom in some places between two parallel-arranged reefs. Such places are also inhabited by *Codium isthmocladum* and *C. dichotomum*.

In addition to the collection from the reef off Pernambuco south of Recife, a small collection was obtained also from the island of Fernando Noronha which lies some 250 miles northeast of Natal.

As has been noted by other investigators (Howe 1928; Taylor 1930), the littoral marine algae of Brazil show strong affinities with those of the West Indies. This is especially evident from the entities reported here. Some forms even range as far north as North Carolina. It is also interesting to note that there is evidently some floristic relation between the algal flora of Brazil and the south Pacific, as has been pointed out by Børgesen for the West Indies (1915–20, 1924).

A total of 116 entities have been identified from this collection. Of these, 33 are new to northern Brazil, and 22 are reported for the first time from Brazil.

MYXOPHYCEAE

Coccogonales—Chamaesiphonaceae

DERMOCARPA PRASINA (Reinsch.) Born. & Thuret.[1] Epiphytic on *Rhizoclonium riparium* and other algae of the reef. Reported here for the first time from Brazil. W. I., Bermuda and Florida.

Hormogonales—Oscillatoriaceae

OSCILLATORIA CORALLINAE Gomont. Epiphytic on *Dictyosphaeria cavernosa* from reef crevices. Reported here for the first time from Brazil. W. I. to Florida and Bermuda.

CHLOROPHYCEAE

Ulvales—Ulvaceae

ULVA FASCIATA Delile. The plants of this species collected on the reef and at Fernando are smaller than *U. Lactuca* var. *rigida* and are not stiff and brittle when dried. There is no tendency for the thallus to be pinnately lobed, but a study of the cross section reveals cells of the center of the blade to be about three times as long as broad and becoming shorter toward the margin. This species grows profusely in beds of silt just below low tide level and on the reef in places where it is not exposed at low tide. Tropical waters the world over.

ULVA LACTUCA L. Same habitats as the preceding species but relatively uncommon. The cells viewed in cross section of the thallus are about as long

[1] Determined by Dr. Francis Drouet.

as wide with no gradation in size from the middle toward the margin. Plants not brittle when dried. World wide in distribution.

ULVA LACTUCA var. RIGIDA (C. Ag.) LeJolis. The most common member of the genus in the areas collected about the reef and at Fernando where it forms large beds of well developed plants. The specimens are very thick and coarse, becoming brittle when dried. It has been previously reported from nearly every station where algae have been collected in Brazil. Common in warm waters of the western Atlantic Ocean.

Siphonocladiales—Cladophoraceae

CHAETOMORPHA GRACILIS Kütz. Common at Recife and Fernando, entangled with other algae, especially *Gelidium rigidum* and *Digenea simplex* in the intertidal zone. Previously reported from Rio de Janeiro, but reported here for the first time from northern Brazil. W. I., and Florida.

RHIZOCLONIUM RIPARIUM (Roth.) Harv.[2] Common in mats of *Bostrychia Binderi* from the reef and Fernando. Reported here for the first time from Brazil. W. I. Probably widely distributed.

CLADOPHORA GRACILIS (Griffiths) Kütz. f. SUBFLEXUOSA Coll.[2] Growing on wall of a cliff exposed intermittently between waves on Fernando. So far as is known, this is the first report of this species south of Florida. General distribution unknown.

CLADOPHORA MEMBRANACEA (C. Ag.) Harv.[2] *Cladophoropsis membranacea* (C. Ag.) Børg. In tufts on large rocks at Fernando and abundantly in depressions and on the inside wall of the reef. Exposed during low tide. This is the first report of this species from Brazil. Common in the W. I. to Florida.

Valoniaceae

ANADYOMENE STELLATA (Wulf.) C. Ag. An uncommon species on the reef. One specimen was found growing in a transverse fissure of the reef just below low tide level. W. I., Bahamas, Bermuda, to Florida.

DICTYOSPHAERIA CAVERNOSA (Forssk.) Børg. Adhering to the inner wall of the reef and in crevices, and at base of boulders at Fernando. A member of the algae of the lower intertidal zone. This species has been reported once previously from Brazil. W. I., Bahamas, Bermuda, to Florida.

CHAMAEDORIS PENICULUM (Ell. & Sol.) Kunze. Growing on silt in lagoon between reef and beach. W. I., Bermuda to Florida.

VALONIA VENTRICOSA J. Ag. One specimen was found concealed in a crack in the reef. This species has been found previously in the Abrolhos Islands in southern Brazil. W. I., Bahamas, Bermuda, Florida.

Siphonales—Bryopsidaceae

BRYOPSIS PENNATA Lamour. Very common in depressions in the reef retaining water during low water. W. I., Bahamas, Bermuda, Florida to North Carolina.

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[2] Determined by Dr. Harry K. Phinney.

Caulerpaceae

CAULERPA CRASSIFOLIA (C. Ag.) f. MEXICANA (Sond.) J. Ag. Commonly washed ashore on Fernando and very abundant on the inner wall of the reef giving it a light-green color. It develops here into large plants, the erect branches attaining a length of 9 cm. from extensive stolons. Collectors in the West Indies report it from considerable depths. In Pernambuco it thrives at low tide levels. The form of this species is reported here for the first time from Brazil. W. I., Bermuda, Florida.

CAULERPA LYCOPODIUM J. Ag. (Figure 2.) This alga superficially appears like a club moss growing on the inner wall of the reef in the intertidal zone.

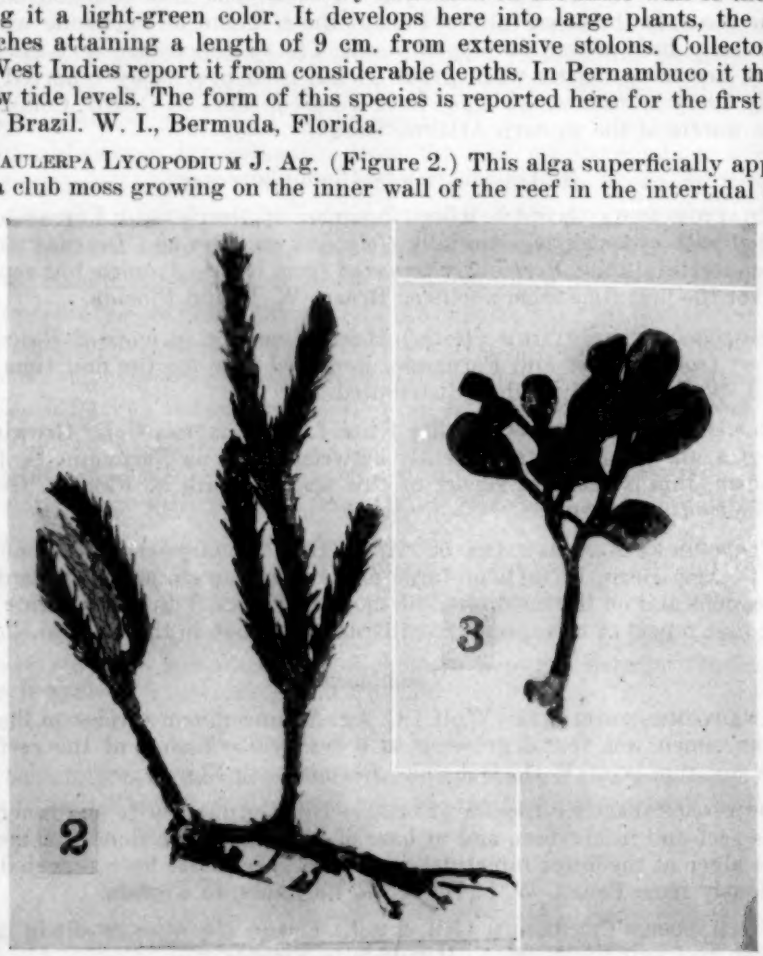

FIG. 2. *Caulerpa Lycopodium* J. Ag. ×1. FIG. 3. *Botryocladia Skottsbergii* Børg. ×1.25.

It was at first mistaken for *C. lanuginosa* J. Ag., with which it has been previously confused. It differs, however, from the latter in having entire ramuli and in the absence of branched hairs on the stolons and erect branches. The ramuli are relatively large with mucronate tips. The erect branches frequently become 15 cm. long. No records have been found of recent collections of this species, but DeToni reports it from Bahia and from Martinique.

CAULERPA PROLIFERA (Forssk.) Lamour. The blades of the thallus of this alga protrude from between other algae covering the various surfaces of the

reef, particularly the inner wall, where some of the plants are exposed during low tide. It was also found growing in silt between large rocks at Fernando. From the Caribbean area Taylor (1942) reports this alga in water of moderate depths, but in Fernando it thrives in the intertidal zone. W. I., Bahamas, Bermuda, Florida.

CAULERPA PUSILLA (Kütz.) J. Ag. This alga was found growing in small green patches in silt in a protected bay at Fernando and in the same kind of habitat between the reef and the beach in Pernambuco. The plants were bright green when collected, but turned dark-red on drying. This species is coarser than *C. verticillata* J. Ag. and has shorter erect branches (about 1 cm. tall) with ramuli more numerous in the whorls, and with numerous short forked hairs. Barbados.

CAULERPA RACEMOSA (Forssk.) J. Ag. var. LAETEVIRENS (Mont.) Weber-van Bosse. This variety grows on both sides of the reef below tide level, and was also found growing from a rocky bottom at Fernando. This is the largest Caulerpa encountered in Brazil. It grows in dense bunches with erect branches sometimes becoming 1 cm. in diameter and 13 cm. long. W. I., Bermuda and Florida.

CAULERPA RACEMOSA (Forssk.) J. Ag. var. CLAVIFERA (Turn.) Weber-van Bosse. This variety grows in more exposed places than any of the other Brazilian caulerpas encountered. In places where it is found on top of the reef it is subjected to considerable drying. It was also found free floating at Fernando. It is a smaller plant than the preceding variety. W. I., Bermuda and Florida.

CAULERPA RACEMOSA (Forssk.) J. Ag. var. UVIFERA (Turn.) J. Ag. This is the smallest of the racemose Brazilian caulerpas. It is found attached to the inner wall of the reef and in less exposed places on top of the reef where it loses its green color (apparently from excessive rains, which bring more freshwater than it can tolerate while exposed to the air) and becomes yellow. Here reported for the first time from northern Brazil. W. I., Bermuda and Florida.

CAULERPA SERTULARIOIDES (Gmelen) Howe. This plumose alga becomes a large plant on the reef and at Fernando, where the erect branches frequently measure 12 cm. in length, and 1.5 cm. wide, growing from an extensive stoloniferous system at low tide levels and protruding from other algae on the inner wall of the reef, or from silt at base of rocks on Fernando. Some of the plants approach the *longiseta* form [*C. sertularioides* f. *longiseta* (Bory) Svedel.], but there are so many gradations to the larger sizes it was decided to place them all in the species. Reported for the first time from northern Brazil. Barbados, Bermuda and Florida.

CAULERPA WEBBIANA Mont. f. TOMENTELLA (Harv.) Weber-van Bosse. Frequently found free floating and entangled with other algae. One cluster was found growing attached to an *Amphiroa fragillissima* in a transverse crevice of the reef. Previous collectors (Børgesen 1913–1914, Collins 1909) from other localities report this species from deep water (to 50 m.). In Pernambuco it was found at low tide levels. W. I., Virgin Islands and Florida.

Codiaceae

CODIUM DICHOTOMUM (Huds.) S. F. Gray. One bed of this species was found on a rock bottom about 5 ft. below low tide level between two parallel-running reefs. However, since large quantities were washed ashore both in Pernambuco and on Fernando Noronha it must be considered common. The utricles average over 180 μ and the tips are moderately thickened. When dried the plants have a wooly appearance. This species has been found wherever algae have been collected in quantities in Brazil and is cosmopolitan in warmer waters.

CODIUM ISTHMOCLADUM Vick. Found among drifting algae near the shore at Fernando. The plants are long and slender, constricted at the bases of the branches, and light green in color. This report is new to Brazil, but this species is known from Venezuela, W. I., Bermuda and Florida.

HALIMEDA DISCOIDEA Decaisne. Scattered plants were found growing on the slopes of the ocean side of the reef in about 3 ft. of water below low tide levels. Since large numbers of plants were found washed ashore both in Pernambuco and on Fernando, it must be considered common in deeper water than the reef algae. This is the first report of this species from Brazil. W. I., Bahamas to Florida.

HALIMEDA OPUNTIA (L.) Lamour. A few specimens were found lodged in crevices in the reef and many fragments were found drifting ashore in both Pernambuco and Fernando. It is probably common in offshore waters. Caribbean area, Bermuda and Florida.

HALIMEDA SIMULANS Howe. In Pernambuco this species was commonly found growing in silt in crevices of the reef sloping toward the ocean about 2 feet below low tide levels. This is the only species of *Halimeda* collected in this area that is common in the shallow water associated with the reef. On Fernando it was growing in muddy silt between the shore and nearby offshore rocks. It was also common among the algae washed ashore. This is the first report of this species from Brazil, but it has been reported previously from Columbia, Caribbean, Gulf of Mexico, and Tropical North Atlantic.

HALIMEDA TUNA (Ell. & Sol.) Lamour. Only one specimen of this species was collected in Pernambuco, growing with *H. discoidea*. Barbados to Bermuda.

PENICILLUS CAPITATUS Lamarck. In Pernambuco, growing on silt in the lagoon between the reef and the beach, and frequently so masked by silt that it was easily overlooked. Because the stipes are shorter than the capitulum the plants of this collection might be considered a new form. The average length of stipe is 13 mm., and the average branching filament of the capitulum is 16 mm. long. The diameter of the filaments of the capitulum is about 180 μ, which would place it in the range of the species to which it is assigned here. This is the first report of this genus and species from Brazil. It has been reported previously from Venezuela to Bermuda.

UDOTEA FLABELLUM (Ell. & Sol.) Howe. In Pernambuco growing on silt in the reef-formed lagoon below low tide level. Washed ashore on Fernando. This species has been reported once previously from Brazil in a northern locality. It is known from as far north as North Carolina.

PHAEOPHYCEAE

Dictyotales—Dictyotaceae

DILOPHUS ALTERNANS J. Ag. A few plants drifted ashore on Pernambuco. Barbados to Bahamas and Florida.

DICTYOTA CERVICORNIS Kütz. In Pernambuco this species grows in abundance in the reef-formed lagoon on a shallow rock bottom, and is very common among the drifting algae both in Pernambuco and Fernando. W. I., Bermuda to Florida.

DICTYOTA CILIOLATA Kütz. Washed ashore on Pernambuco. W. I., Bermuda to Florida.

DICTYOTA DIVARICATA Lamour. Drifted ashore in Pernambuco. Reported here for the first time from northern Brazil. W. I., Bermuda to Florida.

DICTYOPTERIS ARESCHOUGII (J. Ag.) Vick. Thriving in large quantities on rocky ocean slopes of the reef about three feet below low tide level. Occasionally found drifting ashore both in Pernambuco and Fernando. Endemic to Brazil.

DICTYOPTERIS DELICATULA Lamour. Common in the small pools left in the reef when the tide recedes and on silt in the reef-formed lagoon at low tide level. In Pernambuco and Fernando this species is commonly entangled with other algae drifting near shore. W. I., to Bermuda and Florida.

DICTYOPTERIS PLAGIOGRAMMA (Mont.) Vick. Only found on Fernando where a few specimens were washed ashore. The plants here have a very stout axial stalk to which is attached wiry branches. The midrib is very pronounced and is hairy on one side. In addition to the midrib there are many smaller veins that are pinnately arranged from the midrib. W. I. to Bermuda and Florida.

DICTYOPTERIS JUSTII Lamour. This species grows with *D. Areschougii* and may be distinguished from it in living condition by its darker color and smaller habit, and by the presence of a midrib running to the holdfast. In *D. Areschougii* there is always a short stipe present. W. I., Bahamas, Florida.

PADINA GYMNOSPORA (Kütz.) Vick. In Pernambuco this alga forms large beds growing on silt between the reef and the beach. The plants are light brown and the rows of spores alternate with two rows of hairs. Reported here for the first time from northern Brazil. Caribbean, Gulf of Mexico to Bermuda.

PADINA VICKERSIAE Hoyt. This brown alga and the preceding species share the same habitat here, but this one is more rigidly constructed and is usually darker in color. Caribbean area to North Carolina.

SPATOGLOSSUM ARESCHOUGII J. Ag. This large brown alga shares its habitat with *Dictyopteris Areschougii* in protected places about 3 feet below low tide level on the ocean slopes of the reef. Some specimens measure 22 cm. long and 4 cm. broad below the branches. Endemic to Brazil.

SPATOGLOSSUM SCHRÖEDERI (Mert.) J. Ag. Much smaller than the preceding species and with a dentate margin. Attached to rocks below tide level on Fernando and common among the drifting seaweeds both in Pernambuco and Fernando. W. I. to North Carolina.

ZONARIA VARIEGATA (Lamour.) C. Ag. Washed ashore in Pernambuco. This species has been reported throughout the marine algal range in Brazil. W. I. to North Carolina.

ZONARIA ZONALIS (Lamour.) Howe. Growing from a rocky slope in about 2 feet of water at low tide on the ocean side of the reef. W. I., Bahamas, Florida.

Fucales—Sargassaceae

SARGASSUM LENDIGERUM (L.) C. Ag. In Pernambuco this species is very common growing from the silty bottom between the reef and the beach, where its tips are exposed during low tide. W. I., Bahamas, Ascension Island.

SARGASSUM PLATYCARPUM Mont. In Pernambuco, thriving in beds between the reef and the beach below low tide level where it grows from a rock bottom. W. I. to Bermuda.

SARGASSUM POLYCERATIUM Mont. One of the most common algae on the crest of the reef, exposed at low tide between waves. W. I., Bahamas, Florida.

RHODOPHYCEAE

Bangiales—Bangiaceae

ERYTHROCLADIA SUBINTEGRA Rosenv. Epiphytic on several green algae. W. I., Bermuda, Florida.

Nemalionales—Helminthocladiaceae

NEMALION SCHRAMMII (Crouan) Børg. Growing attached to rock bottom about 6 feet below low tide level between two parallel-arranged reefs. The plants were pink when collected, but became yellowish-brown on drying. Some of the branches attain a length of 21 cm. and range from 2–15 mm. in diameter and are irregularly branched. Study of the preserved material showed both antheridia and carpospores present. The medullary filaments are 6–10 μ in diameter, composed of long rectangular cells without intercellular spaces. The assimilative moniliform filaments are more or less dichotomously branched and consist of oval cells 8–15 μ in diameter, and 15–28 μ long. This is the first report of this species from Brazil. W. I.

ACROCHAETIUM COMPTUM Børg. Living endophytically in the preceding species. This is the first report of this species from Brazil. W. I.

LIAGORA CERANOIDES Lamour. Growing attached in a variety of habitats below low tide level on both sides of the reef. This is the first time a definite station has been established for this species in Brazil. W. I., Bahamas, Florida.

LIAGORA VALIDA Harv. Washed ashore in Pernambuco. Reported here for the first time from Brazil. Guadeloupe Island, W. I., Bermuda, Florida.

Chaetangiaceae

GALAXAURA CYLINDRICA (Sol.) Lamour.[3] This calcified alga was abundant

[3] Because of the structural dimorphism in *Galaxaura* discovered by Howe (1917, 1918) and corroborated by Svedelius (1944) some of the species listed here may eventually be reduced when their life histories are better known.

among algae washed ashore both on Fernando and Pernambuco. W. I., Bermuda, Florida.

GALAXAURA MARGINATA (Ell. & Sol.) Lamour. Drifted ashore on Fernando. Barbados, through W. I., Bermuda and Florida.

GALAXAURA OBLONGATA (Ell. & Sol.) Lamour. Drifted ashore on Fernando. W. I., Bahamas, Bermuda, Florida.

GALAXAURA RUGOSA (Ell. & Sol.) Lamour. One specimen found among drifting plants on Fernando has been assigned to this species. W. I., Bahamas, Bermuda, Florida.

GALAXAURA SUVERTICILLATA Kjellman. In Pernambuco this species was rarely found drifted ashore. This is the first report of this species from Brazil. W. I., Bahamas, Bermuda, Florida.

Gelidiales—Gelidiaceae

GELIDIUM RIGIDUM (Vahl.) Grev. This is the most common littoral alga at Pernambuco and Fernando. On the reef it grows in a variety of habitats where it is frequently interwoven with other algae. W. I., Bermuda, Bahamas, Florida.

GELIDIUM CORNEUM (Huds.) Lamour. This species forms dark, tough tufts where it grows at low tide level on the reef. W. I., Bahamas, Florida.

GELIDIUM CRINALE (Turn.) Lamour. Found growing with *Laurencia papillosa* at low tide level on the reef. Maine to Florida, and W. I.

GELIDIUM PUSILLUM (Stack.) LeJolis. Firmly attached to surface of cliff and sprayed at low tide on Fernando. Distribution not well known.

GELIDIUM sp. A light red alga, sparingly branched which in cross section shows the structure of this genus. It has not been possible so far to assign this satisfactorily to any described species.

Cryptonemiales—Corallinaceae

FOSLIELLA LEJOLISII (Rosanoff) Howe. Epiphytic on various species of algae in Pernambuco and Fernando. Northeastern U. S. to Brazil.

MELOBESIA MEMBRANACEA (Esper) Lamour. Epiphytic on various species of algae in Pernambuco and Fernando, often mixed with the preceding species. This is the first report of this species from Brazil. W. I. to Florida.

JANIA ADHAERENS Lamour. This tiny plant is epiphytic on *Sargassum polyceratium* in Pernambuco. W. I., Bahamas, Florida.

JANIA CAPILLACEA Harv. One large tuft washed ashore south of Recife. W. I., Bahamas, Florida, and North Carolina.

JANIA PUMILA Lamour. Epiphytic on *Dictyopteris Areschougii* and *Sargassum polyceratium* from the reef. First report from Brazil. W. I., Bahamas, Bermuda and Florida.

JANIA RUBENS (L.) Lamour. Washed ashore with an entanglement of *Amphiroa fragilissima* and *Dictyopteris delicatula* on reef off Pernambuco. W. I., Bahamas, Bermuda, Florida.

AMPHIROA BEAUVOISII Lamour. Growing in tufts in depressions in the reef. It is uncommon on the reef, but common among the algae washed ashore. This species has a resemblance to *A. rigida* Lamour. var. *antillana* Børg. Distribution not well known.

AMPHIROA FRAGILISSIMA (L.) Lamour. One tuft mixed with the preceding species was found growing in a depression on the reef below low tide level. Fragments of this species were plentiful on the beach. W. I., Bermuda, to North Carolina.

CORALLINA CUBENSIS (Mont.) Kütz. emend. Børg. A very common epiphyte on *Digenia simplex* off Pernambuco. W. I., Bahamas to Florida.

Grateloupiaceae

CRYPTONEMIA CRENULATA J. Ag. Four specimens found washed ashore in Pernambuco. W. I., Florida to North Carolina.

CRYPTONEMIA LUXURIANS (Mert.) J. Ag. Two plants washed ashore in Pernambuco. W. I., Bermuda to Florida.

HALYMENIA FLORESIA (Clem.) C. Ag. Common on rock bottom about 6 feet below low tide level in lagoon between parallel arranged reefs. W. I., Florida to North Carolina.

HALYMENIA FLORIDANA J. Ag. Growing with the preceding species but less common. Reported here for the first time from Brazil. Ranges as far north as North Carolina.

Gigartinales—Nemastomataceae

PLATOMA TENUIS Howe & Taylor. About a dozen small plants found washed ashore in Pernambuco. Caribbean area.

Rhodophyllidaceae

RHODOPHYLLIS GRACILARIOIDES Howe & Taylor. Attached to ocean slopes of reef below low tide level. Known only from Brazil. First report from northern Brazil.

Rhabdoniaceae

RHABDONIA RAMOSISSIMA (Harv.) J. Ag. var. DILATATA J. Ag. Two plants found drifted ashore in Pernambuco. First report from Brazil; W. I., to Florida.

GYMNOGONGRUS sp. A few plants drifted ashore in Pernambuco. On the basis of form and structure this alga undoubtedly belongs to this genus. The plants lack reproductive structures. It is thicker and tougher than *G. tenuis* J. Ag. from the W. I.

Hypneaceae

HYPNEA CERVICORNIS J. Ag. One large specimen found drifting off Pernambuco. Reported here for the first time from northern Brazil. W. I., Bermuda to Florida.

HYPNEA MUSCIFORMIS (Wulf.) Lamour. This very variable alga becomes a coarse plant in Pernambuco, with numerous spiny projections. It grows in large beds on a rocky bottom just below low tide levels in the reef-formed

lagoon. It is very abundant in Brazil. It is an excellent source of Hypnea (agar) jel. Brazil to Massachusetts.

HYPNEA SPINELLA (C. Ag.) Kütz. This is a very common alga growing in mats and sometimes mixed with *Bostrychia Binderi* on the ocean wall of the reef and on cliffs hit by spray at low tide at Fernando. W. I. to Bermuda.

HYPNEA ESPERI Bory. A wiry, spiny tough small Hypnea growing entangled with *Botryocladia Uvaria* on the reef. Chile, Easter Islands.

Gracilariaceae

GRACILARIA BLODGETTII Harv. Growing below low tide levels on rock bottom near the beach in a lagoon formed by the reef. First report here for Brazil. Virgin Islands to Florida.

GRACILARIA CERVICORNIS (L.) Grev. Growing in very turbulent water on ocean slopes of the reef where it is exposed to intermittent pounding waves during low tide. One of the most common algae of the reef. Also found free floating off Fernando, W. I., Bermuda and Florida.

GRACILARIA CORNEA J. Ag. Growing on the ocean side ledge of the reef where it receives a pounding from waves at low tide; also common between the reef and the beach on rocky bottom. In this latter habitat it is a more slender plant than the stubby form of the ledge. Reported only from this station in Brazil. W. I., Bahamas, to Florida.

GRACILARIA CYLINDRICA Børg. Very common on the rock bottom in the lagoon between the reef and the beach. W. I. to Florida.

GRACILARIA CURTISSIAE J. Ag. Growing on the ocean ledge of the reef, and in the lagoon between the reef and the beach where it grows attached to rock bottom. Florida.

GRACILARIA FEROX J. Ag. Thriving on top of the reef in turbulent water, where it is exposed between waves at low tide. W. I., Bermuda to Florida.

GRACILARIA MAMMILLARIS (Mont.) Howe. In Pernambuco forming a part of the carpet with other algae on top of the reef, where it is exposed at low tide. This is the first report of this species from northern Brazil. Guadaloupe to North Carolina.

GRACILARIA ORNATA Aresch. One of the toughest of the algae of the ledges on the ocean side of reef, pounded by waves during low tide. Known only from this station in Brazil.

Rhodymeniales—Rhodymeniaceae

BOTRYOCLADIA UVARIA (Wulf.) Kylin. This olive-brown algae grows in profusion on the ocean side slopes of the reef in the intertidal zone, where it is exposed to pounding waves at low tide. The Brazilian specimens differ from those of the West Indies in that the bladders are about half as large and are essentially sessile. W. I., Florida and North Carolina.

BOTRYOCLADIA SKOTTSBERGII Børg. (Figure 3.) Common on the inner walls and the transverse fissures of the reef intermittently exposed during low tide. A sample of this plant has been submitted to Dr. Børgesen who states that it superficially resembles his described species (1924) but he

reserved a final report pending a microscopic examination. After a study of the original description and herbarium specimens of related species, we have placed it in this species. The type locality is Easter Islands, where it was endemic until this report.

Champiaceae

CHAMPIA PARVULA (C. Ag.) Harv. Epiphytic on other algae about the reef. W. I., east coast of North America as far north as New England.

Ceramiales—Ceramiaceae

CENTROCERAS CLAVULATUM (C. Ag.) Mont. Epiphytic on *Digenia simplex* and growing in tufts on the top of the reef. Also epiphytic on various algae from Pernambuco and Fernando. Tropical Western Atlantic.

CERAMIUM NITENS (C. Ag.) J. Ag. Frequently encountered entangled with other algae of the reef off Pernambuco. First reported here from Brazil. W. I., to Florida.

CERAMIUM RUBRUM (Huds.) C. Ag. A common epiphyte on several algae, especially *Bostrychia Binderi* from both Pernambuco and Fernando. W. I. and Atlantic coast of North America.

GRIFFITHSIA GLOBULIFERA (Harv.) J. Ag. Free floating and mixed with *Dictyopteris delicatula* in Pernambuco. Reported for the first time from Brazil. W. I., and Atlantic coast of North America.

GRIFFITHSIA RADICANS Kütz. One large sterile plant found drifting between the reef and the beach. General distribution unknown.

SPYRIDIA FILAMENTOSA (Wulf.) Harv. One large plant found washed ashore in Pernambuco. W. I. and Atlantic coast of North America.

Rhodomelaceae

LAURENCIA OBTUSA (Huds.) Lamour. One of the carpet algae on top of the reef, exposed at low tide. W. I. to Florida.

LAURENCIA PAPILLOSA (Forssk.) Grev. One of the dominant species on top of the reef, exposed during low tide. W. I. to Florida.

LAURENCIA SCOPARIA J. Ag. Growing with other algae on top of the reef. Bermuda.

CHRONDRIA LITTORALIS Harv. Growing in silt at the base of shore-facing wall of the reef below low tide level. Reported here for the first time from Brazil. W. I. to east coast of the United States.

DIGENEA SIMPLEX (Wulf.) C. Ag. From various habitats in turbulent waters from Pernambuco and Fernando. Usually covered with epiphytic *Centroceras* and *Corallina*. W. I., Bermuda, Bahamas, to Florida.

ACANTHOPHORA SPICIFERA (Vahl.) Børg. This is one of the dominant algae on ledges of the ocean side of the reef, where it is exposed to turbulent waters especially at low tide. W. I., Bahamas, Bermuda to Florida.

BRYOTHAMNION SEAFORTHII (Turner) Kütz. f. DISTICHA J. Ag. A co-dominant alga with *Acanthophora spicifera*. W. I. to Florida.

BRYOTHAMNION TRIQUETRUM (Grelin) Howe. Growing attached to rocks in very turbulent water, exposed intermittently at low tide on Fernando. W. I., Bahamas to Florida.

BOSTRYCHIA BINDERI Harv. Forming mats on vertical ocean walls of reef off Pernambuco and on cliffs at Fernando. Sprayed or lashed by waves during low tides. W. I. to Florida.

BOSTRYCHIA SERTULARIA (Mont.) Howe. On ocean wall of reef, exposed at low tide. Grows in less turbulent places than the preceding species. Bermuda and Bahamas.

BOSTRYCHIA TENELLA (Vahl) J. Ag. One specimen found drifting between the beach and the reef. First report of this species from northern Brazil. W. I., Bahamas, Bermuda to Florida.

HERPOSIPHONIA TENELLA (C. Ag.) Ambronn. Washed ashore on Pernambuco. This is the first report of this species from Brazil. W. I., Bahamas, Florida to North Carolina.

LOPHOSIPHONIA OBSCURA Auct. Commonly found growing interwoven with *Bostrychia Binderi* on ocean walls sprayed at low tide, Pernambuco and Fernando. Reported here for the first time from Brazil. W. I. to Florida.

AMANSIA MULTIFIDA Lamour. One of the members of the algal carpet on the crest of the reef, exposed at low tide. W. I. to Florida.

VIDALIA OBTUSILOBA (Martens) J. Ag. A tough, dark alga and one of the dominant algae of the ocean side ledges of the reef, where it is exposed to turbulent water at low tides. W. I. to Florida.

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EXTENSION OF THE BROWN ALGAL ORDER DICTYOSIPHONALES TO INCLUDE THE PUNCTARIALES

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In 1933 Professor Kylin published a paper entitled "Über die Entwicklungsgeschichte der Phaeophyceen," which formed a landmark in the advancement of knowledge of the brown algae. In addition to contributing much new information on the life histories of some eighteen species, he utilized the available knowledge of the structure and reproduction of the brown algae to build a new system of classification.

Kylin divides the Phaeophyceophyta into three classes and twelve orders. The first class, the Isogeneratae, includes the Ectocarpales[1] (Setchell & Gardner 1922), Sphacelariales (Oltmanns 1922), Cutleriales (Oltmanns 1922), Tilopteridales (Kylin 1917), and Dictyotales (Kjellman 1893). The second class, the Heterogeneratae, includes two subclasses, the Haplostichineae and Polystichineae. To the first of these belong the Chordariales (Setchell & Gardner 1925), Sporochnales (Sauvageau 1926), and Desmarestiales (Setchell & Gardner 1925), and to the second the Punctariales (Kylin 1933), Dictyosiphonales (Setchell & Gardner 1925), and Laminariales (Kylin 1917). The third class, the Cyclosporeae, includes the single order Fucales (Kylin 1917).

Although there was, and still is, uncertainty as to the ordinal position of some of the genera or families, the arrangement of Kylin has met with approval and has been followed by almost all phycologists. One notable exception, however, is Fritsch (1945). He does not accept the orders Chordariales, Punctariales, and Dictyosiphonales, but retains the families composing them in their former position in the order Ectocarpales (cf. Oltmanns 1922). Although agreeing to the separation of the Sporochnaceae and Desmarestiaceae from the Ectocarpales and the establishment of autonomous orders for them, the order Ectocarpales *sensu* Fritsch still includes

[1] An order Ectocarpales was established in 1922 independently by Setchell and Gardner (1922) and Oltmanns (1922). The date of publication of the article by Setchell and Gardner is May 16, but the exact date of appearance of the volume by Oltmanns is not indicated. It seems certain, however, that it was published later than the article by Setchell and Gardner. In volume 44 (1922) of R. Friedländer und Sohn's *Naturae Novitates*, reference to the work by Oltmanns appears for the first time in the November (No. 11) issue (p. 244), whereas reference to the paper by Setchell and Gardner (which was published in the United States of America) appears in the August–September (Nos. 8 & 9) issue (p. 192).

an assortment of algae almost as heterogeneous, in regard both to structure and life history, as it did in the system of Oltmanns (1922).

In the past the classification of the higher categories of brown algae was largely based on structure. Although structure is still of great importance in the separation of related species, genera, families, and, in certain instances, even orders, the system of Kylin offered a notable departure in that it was to a large extent founded upon life histories. In view of the transcendent value of the type of life history as an indicator of phylogenetic relationship in lower organisms, the arrangement of Kylin must be regarded as portraying more accurately the basic relationships among brown algae than do earlier systems.

Much of our knowledge of the life histories of brown algae has been acquired in comparatively recent times. This information was not forthcoming until it had been shown that the complete cycle of life could not be learned unless the plants were grown in culture. To Sauvageau, more than to any other person, we are indebted for leadership in this approach to problems of this kind. Over a period of about thirty years previous to his death in 1936, he contributed a long series of papers dealing with the life histories of Phaeophycophyta. (For a list of his publications, see Dangeard 1937.) The discovery for which he probably is best known to botanists in general is that of the microscopic gametophytic generation of members of the Laminariales in 1915 and 1916.

In 1917 Sauvageau announced the discovery of an alternation of heteromorphic generations in *Dictyosiphon foeniculaceus*. Comprehending the full significance of this, Setchell and Gardner in 1925 utilized this character and that of the method of growth of the sporophytic thallus by means of a single apical cell as criteria for removing *Dictyosiphon* from the Ectocarpales and establishing for it the order Dictyosiphonales.

A family Dictyosiphonaceae had already in 1890 been erected by Kjellman for *Dictyosiphon* and *Gobia*, and in 1895 De Toni had added *Scytothamnus* to it. Setchell and Gardner were of the opinion that *Gobia* and *Scytothamnus* more properly belonged in their newly established order Chordariales. *Scytothamnus*, at least as to its type species *S. australis*, has been shown by Kuckuck (1930) and others to possess a subterminal meristem and it was recently placed by Levring (1941) in the family Chnoosporaceae of the order Punctariales, which is probably the correct place for it. *Gobia*, on the other hand, has been shown by Du Rietz (1940) and Levring (1940), working independently of each other, to be synonymous with *Dictyosiphon*.

Since the time of De Toni, Oltmanns (1922), Kuckuck (1930), and Fritsch (1945) have added one or more of the genera *Coilodesme*, *Delamarea*, and *Cladothele* to the Dictyosiphonaceae. The systematic position of these genera is, however, still uncertain and some authors have placed them in other

families. Although in general structure they agree with *Dictyosiphon*, the method of growth by a single apical cell has thus far been shown to occur in *Cladothele* only (Skottsberg 1921, fig. 15a). According to Reinke (1889–1892), very young plants of *Coilodesme* might possess an apical cell. In later stages, however, he and Kuckuck (1930) both found growth to occur as the result of intercalary cell divisions. Reinke (op. cit., p. 52) says: "Vielleicht wird man finden, das Keimpflanzen von *Coilodesme* eine Scheitelzelle besitzen, aber auch wenn das nicht der Fall sein sollte, würde ich wegen der eigenthümlichen Entwicklung der sporangientragenden Gewebeschichten kein bedenken tragen, *Coilodesme* zu der Dictyosiphoneae zu stellen."

The Dictyosiphonales were placed by Kylin (1933), together with the Laminariales and his newly erected Punctariales, in the subclass Polystichineae of the class Heterogeneratae. A distinguishing feature of the Polystichineae is the formation of true parenchymatous tissues as the result of intercalary longitudinal division of the cells of the thallus.

The justification for recognition of an order Laminariales has, to the knowledge of the writer, not been questioned since its establishment by Kylin in 1917. Whether the Dictyosiphonales and Punctariales ought to be kept apart is, however, less certain. The only feature whereby they are separated is that in the Dictyosiphonales the thallus grows by means of a single initial, whereas in the Punctariales growth is subapical (e.g. *Chnoospora*) or diffuse. However, even in those Dictyosiphonales, such as *Dictyosiphon foeniculaceus*, in which the apical cell apparently remains functional, intercalary transverse divisions are not uncommon and no doubt play an important role in the growth of the thallus. In others, such as *Gobia baltica*, which is synonymous with *Dictyosiphon Chordaria*, young individuals grow by means of a terminal cell, but in older stages the apical cell is functionless and growth is intercalary. Reinke (1889–1892, p. 52) says of this species: ". . . *Gobia* zeigt nur an ganz jungen Individuen ein Wachsthum mit Scheitelzelle, später wächst es ganz intercalar ohne Scheitelzelle, wie auch *Dictyosiphon Chordaria* in seinen älteren Zuständen." In *Cladothele Decaisni* the situation is much as in *D. Chordaria*. Skottsberg (1921, p. 36) remarks of this species: "In *Cladothele* every branch ends in an apical cell (fig. 15a). . . . the apical cell is not an initial in the true sense, but becomes less active at an early date, . . ."

In the opinion of the writer it thus seems best to unite the Punctariales and Dictyosiphonales under the latter name, which has the right of priority. Further support for this view, although indirect, is furnished by the situation in the Chordariales. Here the members of some families grow by means of a single initial cell, whereas in others growth is by an intercalary (trichothallic) meristem.

As thus extended the order Dictyosiphonales would include the families: Striariaceae (Kjellman 1890), Giraudyaceae (Sauvageau 1927), Myriotrichiaceae (Kjellman 1890), Punctariaceae (Kjellman 1883), Chnoosporaceae (Setchell & Gardner 1925), Dictyosiphonaceae (Kjellman 1890).

It is not unlikely that the Punctariaceae (Encoeliaceae of some authors) should be divided into several families as, in fact, has been done by Setchell and Gardner (1925) and others. However, until this can be done along more sharply defined lines than is at present possible, it may be best to recognize but one family.

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BULLETIN OF THE TORREY BOTANICAL CLUB
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A BASIDIOBOLUS PRODUCING ELONGATED SECONDARY CONIDIA WITH ADHESIVE BEAKS

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A maizemeal-agar plate culture which after being permeated with *Pythium ultimum* Trow had been further planted with small quantities of friable leaf mold collected on November 14, 1945, in a deciduous wood near Mercer, Wisconsin, showed after 50 days about a hundred globose conidia scattered sparsely over an area of approximately 75 square millimeters bordering one of the deposits of forest detritus. Nearly all of the globose bodies were empty of protoplasmic contents, and thus were represented only by membranous envelopes many of which had become misshapen from partial collapse (fig. 1, a). The globose envelopes that had suffered no collapse (figs. 2, a; 3, a; 4, a) revealed, like the few globose conidia that retained their protoplasmic contents, a rather broadly protuberant irregularity in their rounded contour, which gave them an unmistakable similarity to the subspherical conidia characteristic of many insectivorous Entomophthoraceae as well as of the few related forms in the genera *Conidiobolus* and *Delacroixia*. Many of the empty globose envelopes were found bearing individually an erect slender conidiophore (figs. 1, b; 2, b; 3, b; 4, b) usually about 300 μ high, on whose tip was supported an elongated ellipsoidal or strobiliform secondary conidium (figs. 1, c; 2, c; 3, c) prolonged at its distal end into a narrow beak which terminated in a relatively large spherical mass of yellow material. While in many instances the empty conidiophore was found denuded (fig. 4, b), and often, besides, had fallen over prostrate on the substratum, it was clear that all of the empty globose conidia had used their contents in producing aloft a secondary conidium of the beaked strobiliform type. In no instance had germination taken place by the production of a mycelial hypha.

Nor was vegetative germination observable in any of the beaked conidia. When these fell on the moist substratum (figs. 5, a; 6, a; 7, a; 8, a) they usually would send up a slender conidiophore (figs. 5, b; 6, b; 7, b; 8, b), most frequently from a position about midway between base and apex, to produce a tertiary conidium (fig. 5, c), which, like its immediate parent, was strobiliform and drawn out distally into a beak surmounted by a subspherical yellowish mass. The same reproductive development would commonly be

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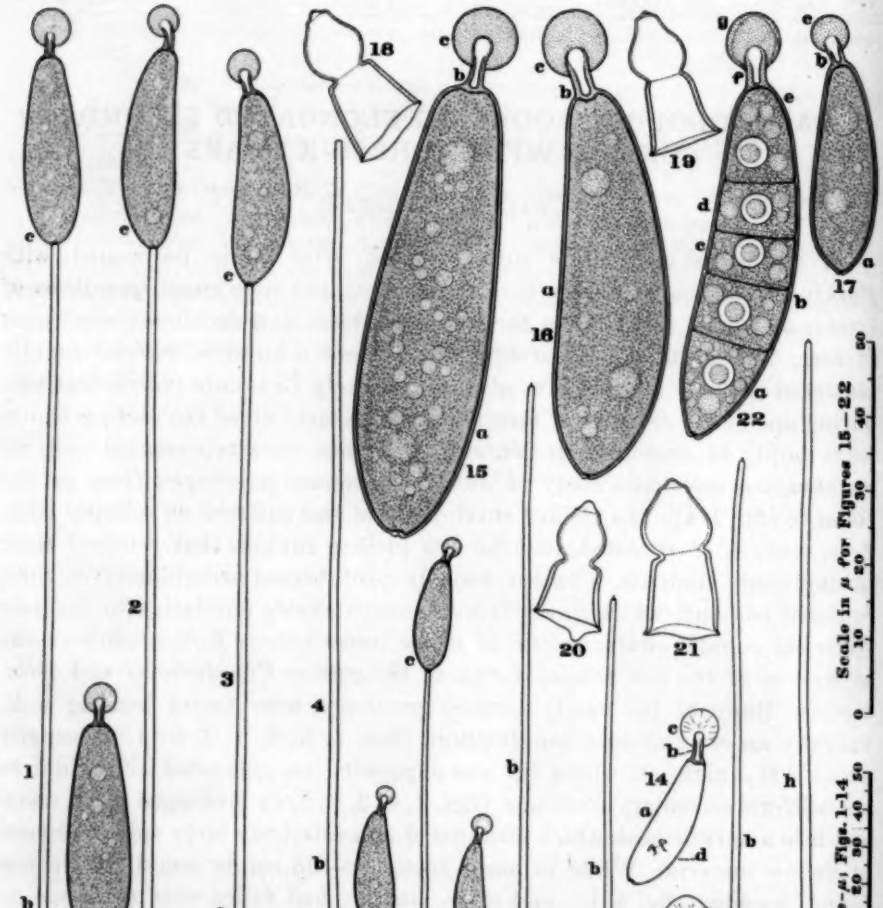
C. Drechsler del.
Scale in μ for Figures 15—22
Scale—μ; Figs. 1-14

repeated a second and a third time, each repetition entailing some reduction in size of the spore; so that whereas the first generation of strobiliform conidia often measured 64 to 73 μ in total length and 14.5 to 17.5 μ in greatest width (figs. 1, c; 2, c; 3, c; 9), many of their descendants (figs. 5, c; 10; 11) showed corresponding dimensions only half as large.

Departures from the usual course of repetitional development were manifest in a number of instances. In one such instance the empty spore envelope of elongate elliptical outline (fig. 12, a) bore in its median region four empty collapsed membranous pouches, one of them being attached by a short hyphal outgrowth (fig. 12, b), the others (fig. 12, c–e) being borne at intervals on a hyphal outgrowth that must have been produced by successive elongation. That these collapsed pouches may originally have had a subspherical shape was strongly indicated in the distal modification of the beak (fig. 12, f) into a globose inflated part (fig. 12, g) that bore a slender sporophore (fig. 12, h) whereon had evidently been produced a conidium of the strobiliform type. The inflated part at the tip of the beak would seem perhaps best interpretable as a somewhat abortive conidium of the globose type interpolated between two generations of strobiliform conidia. The four collapsed membranous

Explanation of figures 1–22

Basidiobolus haptocladus, drawn with the aid of a camera lucida; magnification ×500 in figures 1–14, and ×1000 in figures 15–22. FIGS. 1–3. Globose primary conidia, a, each of which has put forth an erect conidiophore, b, whereon is borne an elongate secondary conidium, c, with its apical beak supporting a mass of yellow adhesive material. FIG. 4. Empty envelope of a globose conidium, a, with the empty membrane of the erect germ conidiophore, b, from which an elongate conidium has become detached. FIG. 5. Elongate conidium, a, which has put forth an erect conidiophore, b, and on its tip has produced an elongate beaked daughter-conidium, c. FIGS. 6–8. Empty envelopes of elongate conidia, a, each bearing an empty erect conidiophore, b, from whose tip a daughter-conidium of elongate type has become detached. FIGS. 9–11. Detached conidia of elongated beaked type, showing differences in size and shape. FIG. 12. Empty envelope of elongate conidium, a, bearing laterally on two short empty hyphal outgrowths the collapsed membranous envelopes of four globose bodies, b–e, and bearing distally on its apical beak, f, a fifth empty globose body, g, whereon is supported an empty erect conidiophore, h, now denuded of the elongate daughter-conidium produced on its tip. FIG. 13. Empty envelope of elongated conidium, a, with terminal beak, b, and flattened body of adhesive material, c; it bears laterally a germ conidiophore, d, which tapers narrowly before widening out to bear an abortive "basidium," e, surmounted by the empty envelope of an abortive globose conidium, f, supporting a sterigma, g, from which an elongate conidium was disjointed. FIG. 14. Empty envelope of elongate conidium, a, with apical beak, b, and mass of adhesive material, c; it bears laterally a short, distally reflexed, empty, tubular membrane, d, left behind after the violent discharge of an expanded "basidium" and globose conidium. FIGS. 15–17. Elongate conidia, a, each with an apical beak, b, whereon is borne a globose mass of yellow adhesive material, c. FIGS. 18–21. Empty membranous remains of expanded distal parts of propulsive conidiophores ("basidia") found lying scattered on substratum after each functioned in the violent discharge of a globose conidium. FIG. 22. Elongate conidium which has become divided internally into five cells or sporangiospores, a–e, each showing a large nucleus near its center; f, apical beak; g, globose mass of yellow adhesive material.

pouches seem likewise interpretable as abortive globose conidia that with respect to function had suffered complete frustration.

Another and somewhat different departure from the usual course of repetitional development was brought to light in a strobiliform conidium whose empty envelope (fig. 13, a), correctly provided at its apex with beak (fig. 13, b) and mass of yellowish material (fig. 13, c), was found bearing in the usual median position an empty conidiophorous filament (fig. 13, d), which at a distance of 35 μ from its origin, on tapering to a width of 1.3 μ, widened out to 2.5 μ and maintained this width for a distance of 20 μ to bear a thick-walled expanded part (fig. 13, e) surmounted by a thin-walled, somewhat globose, empty bladder (fig. 13, f). This bladder bore an empty, blunt, sterigma-like projection (fig. 13, g) from which assuredly a daughter-conidium must have become abjointed. Judging from the narrow apex of the projection, the daughter-conidium most probably was of the beaked strobiliform type. Here, again, the globose bladder may best be construed as a poorly developed abortive conidium of the subspherical type that was interpolated between two generations of beaked conidia.

That, nevertheless, a conidium of the strobiliform type may sometimes give rise successfully to a daughter-conidium of the globose type was inferred from an empty spore envelope (fig. 14, a) which showed a fully characteristic elongated-elliptical outline and at the apex was prolonged into a beak (fig. 14, b) bearing a subspherical mass of yellow material (fig. 14, c). The only membranous part present on this envelope that could have been operative in conveying away the protoplasmic contents was a short lateral tube (fig. 14, d), open at the end, and with its distal portion markedly widened and reflexed; the cylindrical portion of the tube measuring about 2.5 μ in length and width, while its reflexed mouth showed a width of approximately 5.5 μ. As the slightly lipped basal hilum in elongated beaked conidia (figs. 15, a; 16, a; 17, a), with its darkened minute central scar, is usually not more than 2 μ wide, the likelihood that a conidium of this type could have been disjointed from so broad an attachment can be dismissed from consideration. The manner in which the reflexed tube must have come into being was made evident through the presence near the leaf mold of more than twenty thick-walled empty structures (figs. 18–21) consisting individually of a bell-shaped part, slightly flaring at the open mouth, together with a slightly shorter dome-shaped part that at the closed end showed a minute thin-walled protrusion; the two parts being demarcated from one another by a fairly pronounced transverse constriction. The close resemblance of these curious structures to the "basidia" figured by Eidam (10, *pl. 10, fig. 22, a–c*) in the original account of his *Basidiobolus ranarum*, as well as to Thaxter's (20, *pl. 21, figs. 411, a; 412, a*) illustrations of the same objects, identified them unmistakably as thick-walled envelopes of the expanded ter-

minal parts thrown off in the violent discharge of conidiophores pertaining to a species of *Basidiobolus*. Manifestly the reflexed tube on the empty strobiliform conidial envelope represented the proximal portion of such a propulsive conidiophore that was left attached when the expanded distal portion, together with the daughter-conidium borne on it, was projected into the air. The conidiophore here must have been very short since the expanded part had evidently been borne on a narrow stalk only 2.5 μ long. Further, the meager length of the reflexed rim of the empty tube would seem to indicate that rupture of the conidiophore here took place considerably farther toward the base of the expanded part than would seem illustrated by Ingold (13) for *B. ranarum*.

There is reason to believe that in the present fungus the narrower stalk-like part of the propulsive conidiophore may often attain greater length than in the specimen shown in figure 14, d. As the thick-walled expanded part shown in figure 13, e, almost certainly represents an abortive "basidium," the somewhat widened portion of supporting filament immediately below it may very probably have developed as the stalk of the "basidium," whereas the narrowly tapering proximal portion of supporting filament offered more the appearance of having been produced as the prospective stalk of an elongated beaked conidium. Direct observations on the forcible discharge of the "basidium" and globose conidium are lacking, because unfortunately the projection of these bodies on to the transparent agar, evidently from a source some distance within the deposit of leaf mold, had come to an end when the fungus was first seen; and because, further, the repetitional development of conidia on the agar took place, with very few exceptions, by the production of elongated beaked conidia on inert slender sporophores.

Spores corresponding to the beaked conidia of the Wisconsin fungus do not seem to have been ascribed to *Basidiobolus ranarum* in the rather extensive literature on that species. Nor apparently do any references to such spores occur in the less abundant writings on *B. lacertae* Eidam (10, 15), which species Levisohn (14), after ample comparative study carried out with excrement of frogs, toads, salamanders, blindworms, and lizards, concluded should be reduced to synonymy with *B. ranarum*. Mention of elongated beaked conidia likewise seems absent in Fries' original account of *B. myxophilus* (11), a species which its author (12) later seemed inclined to regard as also being identical with *B. ranarum*, on learning that the gelatinous masses in which it developed might have consisted of material voided from the oviducts of frogs. Of problematical import in this connection is a figure of *B. ranarum* given by Eidam (10, *pl. 9, fig. 16*) wherein is shown a globose conidium with a long slender erect germ-conidiophore that supports an expanded structure tapering markedly toward a narrow apex on which is attached a small globose body. The expanded structure was construed by

Eidam as a "basidium" that had begun to bud forth a tertiary conidium. Thaxter (20, p. 145, 146) noted its similarity to the nearly almond-shaped secondary conidia often produced by *Empusa sphaerosperma* Fres., *E. Fresenii* Nowak., and allied insectivorous species. These secondary conidia Thaxter found borne on long slender capillary conidiophores from which they were not forcibly discharged; and he observed them to germinate by means of an irregular hypha that begins "as a drop-like protuberance from the apex of the spore." One of his figures of *E. Fresenii* (20, *pl. 16, fig. 119*) shows a globose primary conidial envelope that has become emptied of its contents in sending up a capillary conidiophore on whose empty tubular membrane is supported aloft an almond-shaped secondary conidium, which, while still attached, has begun to germinate by putting forth a small spherical protuberance at its tip. This figure, as also Eidam's figure referred to, reveals with respect to the outward shape and general arrangement of component parts a suggestive approximation to the asexual reproductive units of the Wisconsin fungus in which a secondary elongate beaked conidium has been produced from a globose primary conidium.

Although the elongate beaked conidia here under discussion appear truly homologous with the almond-shaped conidia of *Empusa Fresenii*, they show some distinctive differences. As far as I have been able to determine they are always terete, never being flattened laterally in any noticeable degree. The beak (figs. 15, b; 16, b; 17, b; 22, f) with which they are regularly provided cannot well be regarded as a product of incipient vegetative germination, seeming rather to represent a product of spore differentiation. In mature conidia it consists of a sturdy narrowed cylindrical prolongation of the spore envelope. It commonly ranges in length from 4 to 8 μ, and in width from 1.5 to 2.5 μ. Its wall is distinctly yellow and except at the distal end has usually a thickness of 0.5–1 μ. The empty and frequently narrow lumen of the beak is separated from the protoplasmic interior of the living cell below by a septum which likewise is thick and distinctly yellow. Distally the tubular wall diminishes pronouncedly in thickness, so that at the very tip it may be discernible only as a thin convex line of demarcation setting off the colorless lumen from the homogeneous globose mass of yellow material, 5–10 μ in diameter, that surrounds the terminal portion of the beak (figs. 15, c; 16, c; 17, c). In some instances the subspherical mass may show at its periphery a perceptibly different shade of coloration, either lighter (fig. 22, g) or deeper than through its interior. After the spore has fallen on the substratum, the mass often flattens out somewhat irregularly and may then show a variable number of radial striations (figs. 6, a; 7, a; 8, a; 13, c; 14, c). These striations strongly recall the radial markings frequently observable in the globose masses of adhesive material utilized by my *Nematoctonus haptocladus* (9) in the capture of nematodes, and very probably likewise merely represent

minute folds formed in a thin film-like outer layer when the mass becomes flattened under external pressure. Parallelism with *N. haptocladus* is further evident in that the yellow material of the Wisconsin fungus is of an adhesive character, and obviously is secreted from the thin-walled distal portion of the beak. Among phycomycetes the glandular conidial beak, together with the globose adhesive mass secreted by it, has an approximate counterpart in my *Stylopage rhynchospora* (4, p. 394–397), where, however, transformation of the conidial beak into a glandular part is more often omitted than accomplished.

Presumably the special function of the adhesive beak is to attach the spore securely to a passing animal. Although a possibility exists that such attachment be serviceable merely in achieving dispersal after the manner of cockleburs (*Xanthium* spp.), analogy with other fungi whose spores are equipped with similar organs while still attached to their sporophores—e.g. *Dactylaria haptospora* Drechsl. (6, p. 456–461) and *Nematoctonus leptosporus Drechsl.* (7)—or whose spores develop comparable adhesive organs after they fall on the substratum—e.g. *Dactylella asthenopaga* Drechsl. (3, p. 496–499) and *Nematoctonus pachysporus* Drechsl. (7)—seems strongly indicative of a parasitic or, perhaps, predaceous relationship. To some degree the fungus would seem to betray a dependence on some other organism also by its failure to grow vegetatively on the agar culture wherein it appeared. In restricting its development to the production of successive generations of spores it showed a behavior much like the behavior that on a few occasions was found displayed by some insectivorous entomophthoraceous forms in similar cultures which had been prepared by adding detritus from herbaceous crop plants evidently containing intermixed remains of parasitized aphids. By way of contrast, when in several instances *Delacroixia coronata* (Cost.) Sacc. & Sydow (1; 19, p. 457) developed from plantings of decaying material, it gave rise to an extensive vegetative mycelium that yielded an abundance of conidia and resting spores.

Among the many elongated beaked conidia that came under observation, two individuals—one of them shown in figure 22—arrested special attention, for instead of giving rise to another spore externally they became divided internally by transverse cross-walls. The five resulting cells (fig. 22, a–e), though not accurately equal in size, showed no great differences in volume. The two subconical or dome-shaped cells at the base and tip (fig. 22, a, e) measured about 13 μ in length, and about 10 or 11 μ in diameter at the circular end directed toward the middle of the spore; while the three intermediate segments (fig. 22, b–d), of cylindrical shape, measured 6.5–8 μ in length and 10–11.5 μ in diameter. Each of the segments contained near the center of its vacuolate protoplast a spherical nucleus, 4–4.5 μ in diameter, which showed a clear hyaline outer layer surrounding a noticeably darker subspherical

nucleolus commonly 2.2–2.5 μ in diameter. Owing to its relatively large size and its ready visibility in an unstained condition within the living cell, the nucleus here had much resemblance to the nucleus of various rhizopods, such as *Amoeba verrucosa* Ehrenb., for example, where similarly a hyaline outer layer surrounds a slightly darker subspherical central body. Eidam remarked on the unusually large size of the nucleus in *Basidiobolus ranarum*, and mentioned being able to see it in unstained living material. He further characterized the nucleolus of his species as being very large, though judging from his figures it would seem to be somewhat smaller in comparison with the entire nucleus than the nucleolus of the Wisconsin fungus. While for the most part, again, Eidam figured the nucleus of *B. ranarum* with an elliptical outline, the nucleus in the conidial segments of the Wisconsin fungus appeared to be very nearly spherical. It seems unlikely, however, that specific differences are concerned here, since in the figures given by Raciborski (18), Olive (17), and Levisohn (14), the nucleus of *B. ranarum* shows considerable variation in shape and in relative size of the nucleolus.

The two segmented conidia were left on the surface of the agar where they had fallen. They were examined at intervals until after 12 days the culture was ruined through burrowing of small annelids. During these 12 days they showed no sign of further change. In becoming divided internally into several cells they evidently developed in accordance with their primitive character as sporangia. The several cells formed within them must be regarded as sporangiospores homologous with the endogenous immotile spores of my *Gonimochaete horridula* (8) as well as with the cells which according to Levisohn's account are liberated from the globose conidial envelopes of *B. ranarum* inside the digestive tubes of frogs and lizards. Moreover, the several cells of the elongated conidium may readily be homologized with the multiple segments of the helicoid hyphal terminations of my *Meristacrum asterospermum* (5), each of which gives rise exogenously, by budding, to a single conidium of rather small size. To the small conidia of *M. asterospermum*, therefore, as also to the similarly small conidia produced plurally on multiple stalks put forth by the large globose conidia of *Delacroixia coronata* and *Conidiobolus Brefeldianus* Couch (2), the multiple spore segments of the Wisconsin fungus would seem to bear the same relationship as the sporangiospores of *Rhizopus* bear to the conidia of *Cunninghamella*.

It is not known whether the leaf mold used in planting my culture contained excrement of any of the animals habitually harboring *Basidiobolus ranarum* in their digestive tracts, for though the material was collected on rolling upland in a site well removed from any pond or permanent stream, some species of frogs and toads roam about so widely that their excrement might be distributed, even if only in meager quantity, almost anywhere. Consequently the source of the detritus provides no certain indication as to

the separateness of my fungus from *B. ranarum;* and, indeed, caution would seem here all the more necessary in view of Möller's report (16, p. 5–8) that several times *B. ranarum* developed spontaneously in decaying plant residues he collected on the side of a forest brook in Brazil. My fungus, however, would appear distinguished decisively from *B. ranarum* by its abundant production of elongated secondary conidia with adhesive glandular beaks. If similar conidia were formed in *B. ranarum,* they could hardly have been overlooked by the several very competent investigators who have given that species prolonged study. Even if the structure which Eidam interpreted as a "basidium" bearing a small tertiary conidium on its tip, should have been, as Thaxter hinted, a conidium of the secondary type occurring in *Empusa Fresenii,* the pronouncedly tapering shape evident in Eidam's figure, and the absence of any indication of a thick-walled cylindrical part below the globose protuberance, would yet offer features quite alien to my fungus. Further, if the particular "basidium" in question were to be construed as a secondary conidium, its nodding posture would relate it more accurately to the secondary conidia of *E. Fresenii* and *E. lageniformis,* which Thaxter described as "borne obliquely on capillary conidiophores," than to the secondary conidia of the Wisconsin fungus, which like those of *E. Lampyridarum* Thaxt. (20, p. 169–170), among insectivorous forms, are "borne vertically on capillary conidiophores," their axes always being in alignment with the supporting hyphae.

Because its adhesive organs are very unusual among phycomycetes, and, besides, almost certainly imply a destructive biological relationship to some species of animal, the fungus is described as new despite the lack of knowledge concerning its vegetative and overwintering stages.

Basidiobolus haptosporus Drechsler, sp. nov. Conidiis primariis incoloratis, globosis vel late ovoideis, plerumque papilla subtruncata praeditis, vulgo circa 25 μ crassis, in maturitate cum "basidio" inflato violenter emissis, mox hypham fertilem erectam 250–325 μ altam basi 3.5–4.5 μ crassam sursum 2 μ latam saepe porrigentibus et in apice ejusdem conidium secundarium gerentibus. Conidiis secundariis saepe in totum 64–73 μ longis, in cellula viventi et rostro vacuo glutinoso consistentibus; cellula viventi incolorata, elongato-ellipsoidea, recta vel leviter curvata, saepe 50–61 μ longa, 14.5–17.5 μ lata, apice ab rostro septo flavo divisa; rostro tubuliformi, 6–8 μ longo, 2–2.5 μ crasso, muro ejus flavo, magnam partem 0.8–1 μ crasso sed sursum rotundato et valde attenuato et guttula globosa materiae glutinosae flavidae 8–10 μ in diametro vestito. Conidiis ordinum tertii et quarti et quinti modo rarius ad instar primariorum globosis denique cum "basidio" violenter emissis, plerumque ad instar secundariorum elongatis rostratisque sed minoribus, interdum tantam modo 35 μ longis et 8 μ latis, denique rostro eorum interdum tantum 4 μ longo et 1.5 μ lato, et hypha fertili germinationis interdum tantum 150 μ alta, basi tantum 2.2 μ crassa, apice tantum 1.2 μ crassa. Cellula viventi conidiorum elongatorum cujusque ordinis quandoque aliquot septis in plura (interdum 5) loculamenta (sporas) divisa.

Habitat in humo silvestri prope Mercer, Wisconsin.

Primary conidia colorless, globose or broadly egg-shaped, usually provided with a blunt protuberance, commonly about 25 μ in diameter, when fully developed regularly discharged forcibly together with the inflated distal portion of the conidiophore, thereupon often producing a secondary conidium erectly at the tip of an erect conidiophore usually 250–325 μ high, 3.5–4.5 μ wide at the base, and 2 μ wide near the apex. Secondary conidia often 64–73 μ in total length, consisting individually of a living cell and an adhesive apical beak; the living cell colorless, elongated, ellipsoidal, straight or slightly curved, often 50–61 μ long, 14.5–17.5 μ wide, delimited distally from the beak by a thick yellow septum; the apical beak tubular, at maturity devoid of protoplasmic contents, commonly 6–8 μ long and 2–2.5 μ wide, its wall yellow, in large part 0.8–1 μ thick but always very thin at the rounded apex, which is surrounded by a globose mass of yellow adhesive material 8–10 μ in diameter. Conidia of the third, fourth, and fifth orders only seldom resembling the primary conidia with respect to globose shape and violent manner of discharge, being usually similar to secondary conidia in shape and beaked apical modification, though of smaller size, sometimes measuring only 35 μ in total length and 8 μ in width, the beak then often only 4 μ long and 1.5 μ wide, and the erect germ-conidiophore frequently extended by them then sometimes measuring only 150 μ in height, 2.2 μ in basal width, and 1.2 μ in apical width; the living cell in elongated conidia of whatever order occasionally becoming divided by several cross-walls into plural (sometimes 5) cells or sporangiospores.

Occurring in deciduous leaf mold near Mercer, Wisconsin.

UNITED STATES DEPARTMENT OF AGRICULTURE
BELTSVILLE, MARYLAND

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ANTILUMINESCENT ACTIVITY OF ANTIBACTERIAL SUBSTANCES

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The usual test for the presence of an antibacterial substance depends upon the inhibition of the growth of bacteria by it, although test methods based upon inhibition of production of nitrite (Goth & Bush 1944), of hemolysin (Rake & Jones 1943), and of reduction of methylene blue (Reid & Brewer 1946) by bacteria have been used. The observation that the luminescence of photobacteria is decreased greatly by certain antibacterial substances but not by others makes the photobacteria useful both for quantitative determinations and for characterization of antibacterial substances.

The antiluminescent test for antibiotic substances was first used by Rake, McKee and Jones (1942) who devised a 30-minute test for aspergillic acid and showed that penicillin was without antiluminescent activity. The test was valuable also for indicating the presence of a small amount of aspergillic acid in the presence of a much larger amount of a penicillin (McKee, Rake & Houck 1944). Nine of fourteen antibiotic substances were shown to be antiluminescent (Rake, Jones & McKee 1943). Only five of the fourteen substances however, were crystalline; and the activities of the others may have been caused in part by impurities. The *Photobacterium* test was used by Atkinson and her colleagues (1944) to follow the progress made in the isolation and crystallization of the antibacterial substance, "penicidin," a product of an unidentified species of *Penicillium*. The speed and specificity of the antiluminescent test suggested that it might have wide applicability in differentiating antibacterial substances as well as for quantitative determinations of some of them.

MATERIALS AND METHODS

Organism. Two strains of *Photobacterium Fischeri* were obtained from G. Rake and used in several preliminary tests. Since the strain labeled "Doudoroff" gave a luminescence considerably greater than the other strain, it was chosen for further use. All data reported in this paper are based on work done with the Doudoroff strain.

Stock Culture. Stock cultures were maintained in an artificial seawater broth in which the bacteria were viable, though not luminescent, for at least six months at 15° C, and on the modified Egorova-Yarmolink (1945) agar (E–Y agar) on which they were luminescent for about one month and viable for more than six months at 15° C.

The E–Y agar, as modified by the substitution of distilled water for the fish extract and Bacto-peptone for the Witte peptone, is: NaCl 30 g., Bacto-peptone 10 g., asparagine 5 g., K_2HPO_4 1 g., $MgSO_4 \cdot 7H_2O$ 0.5 g., agar 20 g., water 1000 ml.; pH after sterilization 6.9. A broth, E–Y broth, was also used in certain experiments; this contained the same concentrations of salts, peptone, and asparagine as the agar medium.

Test Medium. The test medium was the artificial sea-water broth used by Rake, McKee and Jones (1942).

	Artificial sea-water broth
NaCl	26.7 g.
KCl	0.71 g.
$CaCl_2$	1.15 g.
$MgCl_2 \cdot 6H_2O$	5.11 g.
$MgSO_4 \cdot 7H_2O$	6.81 g.
Bacto-peptone	2 g.
Water, distilled	1000 ml.
pH	6.2–6.6

The media were sterilized by heating at 120° C for 15 minutes. A flask containing 100 ml. of medium was inoculated with bacteria taken from an agar slant or with several milliliters of solution from a tube of sea-water broth which had grown for 48 hours or longer at 15° C. The inoculated flask was then incubated at 15° C for 48 hours with frequent shaking to give a brightly luminescent suspension of bacteria.

Temperature of Incubation. Although the curves given by Johnson, Eyring and Williams (1942) showed the luminescence-intensity of *Achromobacter Fischeri* to be five times as great at 25° C as at 15° C, the Doudoroff strain of *P. Fischeri* glows more strongly in both E–Y broth and sea-water broth at 15° than at 25° C. The growth of *P. Fischeri* in artificial sea-water broth, as measured by turbidity of the solution after incubation for 48 hours, was best at 20° C, slightly less at 15° C, about 75 per cent as much at 25° C as at 20° C, and none at 30° C. The luminescence of the cultures grown at 15° C and 20° C was about equal and considerably greater than that of the culture grown at 25° C, although the difference was small after only 24 hours of incubation. Rake, McKee, and Jones incubated their tests at 25° C, and Atkinson and co-workers, using a strain obtained from Rake, at 16° C. The tests to be reported here were incubated at 15° C.

Oxygenation. The full luminescence of a suspension of the bacteria developed only when an adequate amount of oxygen was present. The tubes of a test were shaken to aerate them just before a test was read. Vigorous sidewise shaking of the racks of tubes provided sufficient oxygen.

Concentration of Bacteria. The concentration of the bacteria can influence decidedly the minimum concentration of antibacterial substance that causes suppression of luminescence. This is important only when abso-

lute values are used, as in certain identification procedures. The effect of concentration of bacteria on the sensitivity of the tests will be discussed later when the activities of tolu-p-quinone, aspergillic acid, and patulin are considered in detail.

Serial Dilution Test. Only the geometrical-series dilution test (Rake, McKee & Jones 1942; Kavanagh 1947a) was performed with *P. Fischeri*. In each tube (12 × 75 mm.) was placed 0.5 ml. of the artificial sea-water broth; the serial dilutions of the antibacterial substances were made, and, when all of the dilutions of a set of tests had been made, 0.5 ml. of a 48-hour culture of the *Photobacterium* was added as rapidly as possible to each tube. The racks of tubes were shaken to mix and to oxygenate the solutions and were placed immediately at 15° C. After the tests had been at 15° for the appropriate time, the racks were shaken to aerate the solutions, and the number of non-luminescent tubes was counted. The reading of the test was done with the unaided, dark-adapted eye in an absolutely dark room. The dilution of the antibacterial substance was calculated from the number of non-luminescent tubes, the first tube representing a dilution of 4. Since all the data reported were obtained by the geometrical-series dilution method, the concentrations can be in error by a factor of 2.

Substances and Sources. The antibacterial substances were obtained from the following: aspergillic acid from G. Rake of the Squibb Institute for Medical Research; the antibiotic from *Arctium minus* and citrinin from J. H. Bailey of the Winthrop Chemical Company; 4,6-dimethoxy-toluquinone from Harold Raistrick; dihydrostreptomycin trihydrochloride (M 2216-H2, about 740 μg./mg.) from O. Wintersteiner of the Squibb Institute; gliotoxin and desthiogliotoxin from J. D. Dutcher of the Squibb Institute; "Hogeboom and Craig No. 1" from L. C. Craig; kojic acid from Commercial Solvents Corporation; mycophenolic acid from Harry Sobotka; patulin, penicillic acid and spinulosin from Harold Raistrick; the crystalline salts of the penicillins from the Commercial Solvents Corp.; streptomycin trihydrochloride (M2213, 840 μg./mg.) from O. Wintersteiner; streptomycin trihydrochloride–calcium chloride double salt (109 X 28 C, 715 μg./mg.) and hydrogenated streptomycin trihydrochloride (144 X 390 I, 800 μg./mg.) from the Research Laboratories of Parke, Davis & Co.; and streptothricin (495 units/mg.) from R. T. Major of Merck and Co. The "Hogeboom and Craig No. 1" (Hogeboom and Craig, 1946) was thought by Doering, Dubos, Noyce and Dreyfus (1946) to be identical with their "ustin." The activities of the dihydrostreptomycin and of the hydrogenated streptomycin were identical when tested by the methods used here and are given in the table under dihydrostreptomycin. The 2-methyl-1,4-naphthoquinone and 2-methyl-1,4-naphthohydroquinone diacetate were commercial products and were used

as received. The tyrothricin was a commercial preparation and was a mixture of unknown proportions of gramicidin and tyrocidine. The two naphthoquinones and tolu-p-quinone were Eastman products that had been recrystallized shortly before using. The hydrogen peroxide was prepared by diluting Merck "Superoxol" with water. Biformin (Robbins, Kavanagh & Hervey 1947a), cassic acid (Robbins, Kavanagh & Thayer 1947), and pleurotin (Robbins, Kavanagh & Hervey 1947) were isolated in this laboratory. The biformin was the purest obtained; the others were crystalline.

The activities are expressed as the minimum antiluminescent concentration in micrograms per milliliter and are for the substances as received, except for the streptomycin and dihydrostreptomycin which are expressed as the free base. The solutions were used without sterilization or after passage through a small Seitz filter pad. When the solutions were sterilized, the first 2 ml. through the filter were discarded and the next 3 ml. collected for use. The solutions were used as soon as possible after they were made because dilute solutions of the quinones, pleurotin, and patulin, at least, are not stable indefinitely.

All the solutions, except the penicillins, were stored in the dark at 11° C when not in use. The penicillins were dissolved in pH 6.7 phosphate buffer and stored at 4° C in a refrigerator.

RESULTS AND DISCUSSION

Antiluminescent Activity. The minimum antiluminescent[1] concentrations of the 26 antibacterial substances active against *P. Fischeri* are given for five different periods of incubation in table 1. The observations of Rake, Jones and McKee (1943) obtained at 25° C and after an incubation period of 0.5 hour are included. The antibacterial activities[2] (Kavanagh 1947) of the substances against the Heatley strain of *Staphylococcus aureus* (ATCC 9144) and *Escherichia coli* (ATCC 9637) are given in the last two columns of table 1, for comparison with the antiluminescent activity.

The antibacterial substances can be placed in one of four groups[3] on the basis of the time course of antiluminescent action.

1. Inactive: Arctium minus, 2-methyl-1,4-naphthohydroquinone, the penicillins, kojic acid, mycophenolic acid, and desthiogliotoxin.
2. Inactive at first, or giving incomplete "blacking-out" for 3 hours but

[1] Procedures for using photobacteria in an antibacterial test are given elsewhere (Kavanagh 1947a).

[2] The 2-methyl-1,4-naphthohydroquinone diacetate was not antiluminescent at 40 μg./ml. and was inactive against *S. aureus* at 800 μg./ml. The desthiogliotoxin was not antiluminescent at 250 μg./ml. and was inactive against *S. aureus* at 500 μg./ml.

[3] The test method does not distinguish between activities of 250 and 256 micrograms/ml. or, for that matter, between 250 and 400 micrograms/ml. The activity listed in table 1 as "> 250" is interpreted as more than 256; how much more is not known.

TABLE 1. *Minimum antiluminescent concentration of antibacterial substances in micrograms per milliliter.*

Antibacterial substance	*Photobacterium Fischeri*						*Staph. aureus*	*Esch. coli*
	10 min.	1 hr.	2 hr.	3 hr.	24 hr.	½ hr.		
"Aretium minus"	> 250	> 250	> 250	> 250	> 250	.....	60	.....
Aspergillic acid	.....	2	2	2	2	15	8	62
Biformin	9	0.34	0.34	0.34	0.17	.....	0.3	1.7
Cassic acid	64	64	32	32	16	.....	8	1000
Citrinin	256	128	64	32	16	.....	16	1000
Dihydrostreptomycin	> 400	> 400	> 400	> 400	100	.....	0.03	0.25
4,6-Dimethoxytoluquinone	16	16	16	16	2	.....	0.12	250
Gliotoxin	32	32	8	8	2	17	0.12	25
"Hogeboom and Craig No. 1"	> 25	25	12.5	12.5	> 25	.....	6	> 50
Hydrogen peroxide	12	6	6	6	6	.....	8	10
Kojic acid	> 2500	> 2500	> 2500	> 2500	> 2500	.....	1250	2500
2-Methyl-1,4-Naphthoquinone	3.3	3.3	3.3	3.3	3.3	.....	1.7	200
Mycophenolic acid	> 500	> 500	> 500	> 500	> 500	.....	250	500
1,2-Naphthoquinone	0.4	0.4	0.8	0.8	1.6	.....	8	25
1,4-Naphthoquinone	0.4	0.4	0.4	0.4	0.4	.....	8	25
Patulin	256	8	2	2	0.5	22	8	8
Penicillic acid	128	64	16	16	4	.....	16	64
Penicillin G	> 500	> 500	> 500	> 500	> 500	.....	0.016	16
Penicillin X	> 1000	> 1000	> 1000	> 1000	> 1000	.....	0.03	16
Pleurotin	32	16	8	8	16	.....	1	> 500
Spinulosin	64	64	125	125	125	.....	64	> 250
Streptomycin	> 400	> 400	> 400	> 400	100	.....	0.03	0.25
Streptothricin	> 300	> 300	> 300	> 300	150	.....	0.1	0.1
Sulfanilamide	750	750	375	375	3000	56	3000	.....
Tolu-*p*-quinone	1	1	1	1	2	3940	1	25
Tyrothricin	> 125	.....	.....	> 125	125	0.11	4	.....
						> 500		

active after 24 hours of incubation: cassic acid, streptothricin, tyrothricin, streptomycin, and dihydrostreptomycin.

3. Active immediately, the activity increasing with increasing duration of incubation: citrinin, gliotoxin, patulin, and penicillic acid.

4. Activity attaining a near maximum value in one hour or less, and

(a) remains constant or increases slightly in the 3–24 hour period: aspergillic acid, biformin, 4,6-dimethoxytoluquinone, hydrogen peroxide, 2-methyl-1,4-naphthoquinone, and 1,4-naphthoquinone; or,

(b) decreases somewhat on further incubation: 1,2-naphthoquinone, pleurotin, spinulosin, sulfanilamide, and tolu-p-quinone.

Antiluminescent activity seems to be unrelated to a particular type of antibacterial activity. The substances in groups 1 and 2 have neither chemical properties nor antibacterial activities in common. In group 3, the two compounds that were chemically related, patulin and penicillic acid, being unsaturated lactones and unsaturated ketones, showed identical time-courses of antiluminescent action after the first hour. Their relative antiluminescent activities were the same as their relative antibacterial activities against *Esch. coli*. The unsaturated ketone may be the reactive group rather than the unsaturated lactone, since citrinin and the substances from *Arctium minus*, which may be unsaturated lactones, behave in a different manner. In group 4, the quinones, without exception, showed maximum activity within 10 minutes or less after mixing with the suspension of bacteria. The other members of this group did not act quite so rapidly as the quinones. The decrease in activity with increasing time of incubation exhibited by several of the quinones, pleurotin, and sulfanilamide may be due to growth of resistant bacteria, or to destruction of the antiluminescent substance.

Antiluminescent activity could not be attributed to a particular grouping of atoms since these antiluminescent substances did not have a group common to all. The molecules could not be modified much, however, without destroying activity, as was indicated by the removal of the sulfur atoms from gliotoxin and the reduction of 2-methyl-1,4-naphthoquinone to the naphthohydroquinone. These changes also removed the antibacterial activity against *Staph. aureus*. Antibacterial activity, while it increases the probability of antiluminescent activity, does not make it certain, for the penicillins and the substance from *Arctium minus* were not antiluminescent. Most of the substances listed in table 1 presumably react with sulfhydryl groups since their antibacterial activity is destroyed by cysteine. However, sulfhydryl reactivity alone is not sufficient to cause antiluminescent activity, for both penicillin and the agent from *Arctium minus* react with cysteine and both are inactive as antiluminescent agents. Both streptomycin (which is inactivated by sulfhydryl) and dihydrostreptomycin (which is not inactivated by sulfhydryl) are feebly antiluminescent.

Although the penicillins were inactive in this antiluminescent test, they

showed good activity (8–16 μg./ml.) in an antibacterial test using *P. Fischeri* (Kavanagh 1947a). Thus the penicillins were active against growing cultures of *P. Fischeri* and inactive against cells that were not growing just as Lee, Foley and Epstein (1944) showed was true for *Staph. aureus*.

Quinones. Because of the high and immediate activity of tolu-p-quinone, it was of interest to compare substituted and unsubstituted quinones as inhibitors of luminescence. Tolu-p-quinone and two derivatives, and two naphthoquinones and one derivative, were tested at equal molecular concentrations. The minimum inhibitory concentrations in micromoles per liter after 10 minutes and 1 hour were 2.5 for tolu-p-quinone, 1,2-naphthoquinone, and 1,4-naphthoquinone; 20 for 2 methyl-1,4-naphthoquinone; 100 for 4,6-dimethoxytoluquinone, and 330 for 3,6-dihydroxy-4 methoxytoluquinone (spinulosin). Substitution decreased the antiluminescent activity of the quinones but not the speed with which they reacted. The number and kinds of substitution are too few to justify extensive speculation about the reasons for the differences in activity between substituted and unsubstituted quinones.

Antibacterial Action of Antiluminescent Substances. Possibly the large increase in the activity of aspergillic acid, biformin, and patulin when the incubation period exceeded 10 minutes occurred because the bacteria were killed. To test this assumption, 0.007 ml. of broth was transferred from each "blacked-out" tube to 7 ml. of sea-water broth or E–Y broth and the tubes of broth incubated at 15° C for four days with frequent inspections for signs of growth of bacteria. The length of the incubation period before the first appearance of luminescence in the transfers was approximately proportional to the number of living cells in the "blacked-out" tube from which the transfer was made. A concentration of antibacterial substance that killed 99 per cent of the bacteria was considered to be bactericidal. The bactericidal concentration determined by this method may have a large error and the concentrations found in different experiments differed considerably. A representative sample of the results is given in table 2.

TABLE 2. *Bactericidal and Antiluminescent Activities of Four Antibacterial Substances.* Concentrations are expressed in micrograms per milliliter.

Substance	Bactericidal				Antiluminescent			
	10 min.	1 hr.	3 hr.	24 hr.	10 min.	1 hr.	3 hr.	24 hr.
Aspergillic acid	—	> 250	> 250	60	250	16	8	8
Biformin	—	> 3.4	> 3.4	3.4	> 3.4	0.4	0.2	0.2
Patulin	—	64	64	8	250	8	2	0.5
Tolu-p-quinone	4	4	4	8	0.5	1	1	2

The bactericidal concentration of three of the substances is considerably higher than the antiluminescent concentration. The slow development of antiluminescent action of aspergillic acid, biformin and patulin, then does not result from death of the cells. Tolu-p-quinone is unique in causing death so quickly and at such small concentration which, however, is about 8 times the 10-minute antiluminescent concentration. The lethal concentration of each substance decreased with increased duration of exposure to it.

Concentration of Bacteria. The effect of concentration of bacteria upon activity of aspergillic acid, patulin, tolu-p-quinone, 4,6-dimethoxy-toluquinone, and spinulosin was determined for undiluted cultures and for cultures diluted[4] 8 times with sea-water broth. The diluted culture required the same concentration of 4,6-dimethoxy-toluquinone; from one-half to one-

TABLE 3. *Antiluminescent concentration of tolu-p-quinone in micrograms per milliliter for four different concentrations of bacteria.*

Relative concentration of bacteria	Duration of Incubation of					
	P. Fischeri					*Staph. aureus*
	10 min.	1 hr.	2 hr.	3 hr.	24 hr.	24 hr.
1	0.5	0.5	0.5	0.5	1	4
0.5	0.25	0.25	0.25	0.25	1	4
0.25	0.125	0.125	0.25	0.25	0.5	2
0.125	0.0625	0.0625	0.0625	0.0625	0.5	4

fourth the concentration of aspergillic acid, patulin, and spinulosin; but only one-eighth the concentration of tolu-p-quinone required by the undiluted culture. The exact proportionality between concentration of bacteria and antiluminescent concentration of tolu-p-quinone was investigated further by measuring the inhibitory concentration for four concentrations of bacteria with the results given in table 3.

For both the ten-minute and one-hour inhibitions, the number of molecules of tolu-p-quinone per bacterial cell required to inhibit luminescence was constant at about 10^7. The data presented in table 3 certainly support, as well as can be expected of the method, the hypothesis that it is the number of molecules per bacterial cell and not the concentration of tolu-p-quinone that determines inhibitions of luminescence but not the antibacterial action against *Staph. aureus*. To prove this, more exact methods of measuring inhibition than were used in this work must be used.

These results emphasize the necessity of using the same concentration of bacteria in all determinations if the absolute value of the inhibitory concen-

[4] The luminescence of the diluted culture was very faint and the tests were difficult to read with consequent increased uncertainty of the end-point.

tration is to have meaning. An alternate and preferable procedure, to be used when possible, is to include standards in each series of assays and to compute the concentration of the unknowns in terms of the standards. It is also quite obvious that the standard must be the substance that is being assayed.

Mode of Action. The luminescent mechanism of bacteria has intrigued a number of investigators, some of whom have developed rather elaborate and detailed theories about it. Studies of the quenching of luminescence by a diverse group of chemical substances and by the effects of temperature and pressure on the degree of inhibition have supplied the data needed to test several hypotheses of inhibition of luminescence (Johnson et al. 1945). The antibacterial substances furnish a chemically different, and much more active, group of inhibitors of luminescence than those that have been used. Aspergillic acid, for example, is about 1000 times as effective as an equal molar concentration of sulfanilamide in inhibiting the luminescence of *P. Fischeri.*

Consideration of three of the types of inhibition of luminescence shown by the antibacterial substances suggests that the inhibition can occur at three, if not more, different points in the chain of reactions connecting the primary energy-furnishing metabolite with the emission of light.

The inhibition of luminescence by tolu-p-quinone is so rapid that it is complete by the time the solution of tolu-p-quinone and the suspension of bacteria are completely mixed. If the tolu-p-quinone competed with luciferin for space on the luciferase molecule, the effect of the addition of the quinone could be immediate. In competition between quinone and luciferin, the quinone, at a sufficiently large concentration, could occupy nearly all of the space on the luciferase thus permitting only inappreciable luminescence. The minimum concentration of tolu-p-quinone that causes complete blacking-out, as judged by visual observation, is 10^{-8} mole per milliliter which is, however, about 10^{7} molecules per bacterium.

Luciferin is known to be destroyed by oxidizing agents (Anderson 1936). Toluquinone and the other quinones are oxidizing agents and could be antiluminescent by oxidizing the luciferin. The exact proportionality between the number of bacteria (and presumably of the number of molecules of luciferin) and the number of molecules of tolu-p-quinone that stops luminescence would be expected if the luciferin were oxidized by the toluquinone. However, if the normal reduction potential of luciferin given by Harvey (1941) is correct, the 1,4-naphthoquinone would not be nearly as effective in oxidizing luciferin as tolu-p-quinone and yet these two quinones are equally antiluminescent. When all six of the quinones are considered, there is no correlation between the normal reduction potential and minimum antiluminescent concentration just as there is no relation between the poten-

tial and the antibacterial activity against *Staph. aureus* and *Esch. coli* (Page & Robinson 1943; cf. table 1).

The inhibition of luminescence caused by aspergillic acid develops much slowly than that caused by tolu-p-qpinone. The time required, from one-half to one hour, suggests that the chain of reactions was blocked by the aspergillic acid at a point for enough removed from the final stages of the luminescent reaction to permit luminescence for one-half hour before the accumulated store of intermediates was exhausted. Once the critical concentration of aspergillic acid has been reached, increasing the concentration does not lessen the time required for the development of the inhibition of luminescence. The minimum inhibitory concentration of aspergillic acid is $2 \cdot 10^{-8}$ moles per milliliter, or about the same as that of tolu-p-quinone.

The action of citrinin, gliotoxin, patulin, and penicillic acid seems to be different from that of the other two groups of substances discussed. An immediate inhibition by high concentrations of the antiluminescent substance, presumably, is the result of blocking of a step near the final one leading to emission of light. The inhibition developed slowly at low concentrations could result from blocking a step far removed from the final one. Since the effect of this blocking develops slowly and the inhibitory concentration decreases with increasing time of exposure to the inhibitor, the inhibition could be one that decreased the rate of, but did not stop, the production of an essential intermediate. The higher the concentration of inhibitor, the greater the decrease in rate of production of intermediate and the sooner the concentration of it is reduced by normal metabolic processes to the point where it becomes the factor limiting luminescence.

Characterization of Antibacterial Substances. One of the problems that confronts anyone who works with the antibacterial substances formed by many different organisms is identification of each of the substances. They need to be characterized sufficiently well by methods applicable to impure preparations that their identity, or lack of it, with known substances can be established. Antiluminescent activity is particularly useful because it frequently is not proportional to antibacterial activity of the substance as measured against the usual Gram-positive and Gram-negative bacteria. In applying the test to culture fluids and other preparations containing unknown concentrations of the active substance, relative activities are computed and compared with those computed from the data in table 1. Two kinds of relative activities are useful, those relative to the 24-hour antiluminescent activity, and those relative to antibacterial activity against Gram-positive or Gram-negative bacteria. For example, the concentration that is antiluminescent at 24 hours can be compared with the concentration that inhibits growth of *Staph. aureus* for 24 hours.

SUMMARY

1. Twenty of the 27 antibacterial substances were antiluminescent when tested against *Photobacterium Fischeri*. They varied greatly in speed of action and in effectiveness.

2. The substances that were antiluminescent did not have a common chemical group to which the activity could be ascribed. Ability to react with sulfhydryl groups was not a sufficient condition for antiluminescent activity; the quinones inhibited luminescence most rapidly; the three unsubstituted quinones were equally active, and were active at a low concentration.

3. The antiluminescent activity of a compound does not necessarily parallel its antibacterial activity against *Staphylococcus aureus* or *Escherichia coli* but frequently does.

4. Several of the antiluminescent substances are bactericidal.

5. The minimum antiluminescent concentration of tolu-p-quinone was found to be exactly proportional to the number of bacteria present. The activity of other substances was much less affected by bacterial concentration.

6. The antibacterial substances seem to affect the luminescent mechanism at two or three places in the chain of events that results in luminescence.

7. Antiluminescent activity may be useful in characterizing an antibacterial substance before it has been isolated in pure form and in following it quantitatively during isolation and purification.

NOTE: After the above paper had been sent to the printer, the following material was tested.

A sample of pure, crystalline helvolic acid (fumigacin) was obtained from E. A. Doisy of St. Louis University. The test was not satisfactory because the test-medium was saturated with helvolic acid even at a concentration of 5 μg/ml. The fumigacin which was active at 273 μg/ml. (table 1) was contaminated with about 20 per cent of gliotoxin fractions (Menzel, Wintersteiner & Hoogerheide 1944; Waksman & Geiger 1944). The presence of 6.2 per cent of gliotoxin in the sample could account for the activity.

The following line should be inserted in table 1 between gliotoxin and "Hogeboom and Craig No. 1."

Helvolic acid	>5	>5	>5	>5	>5	273	1	>1000

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NEW YORK

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TORREYA

BOOK REVIEW

A Textbook of Systematic Botany. (3rd ed.) By Dean B. Swingle. i–xv, 1–343. *f. 1–106.* New York: McGraw-Hill Book Co., Inc. 1946. $3.50.

There is perhaps little point in completely reviewing this edition of a well known and widely used textbook except to examine it in the light of the publisher's note on the dust jacket which states that it "meets the demand for a textbook that approaches the subject by way of genetics, ecology, cytology, and geography."

While it is admitted that mention of these items as they affect a study of systematics does differentiate this edition from the earlier ones, one cannot help but regret that even more consideration was not given them. However, it should perhaps be held in mind that it may not have been Professor Swingle's intention that this text be addressed to advanced students but, rather, to beginners who, presumably, would have no more background than a first course in General Botany. This, therefore, would limit the extent to which he could pursue these highly important topics. The mere fact that one finds them more than casually mentioned in a textbook of systematics is encouraging.

In passing, it would seem that attention should be called to a feature by no means limited to the present text. In my own way of thinking it is a too-common practice to attempt to combine a course in Systematics with one in Local Flora. In fact, in all too many institutions the course listed in the catalog as "Plant Taxonomy" usually simmers down to one in Local Flora—the identification of the plants of the immediate area. A familiarity with the plants of one's region is a needed part of any taxonomist's training, but it certainly is not plant taxonomy in its broadest sense.

It is immediately obvious, when an author approaches the problem of a general textbook in taxonomy, that there must be some selection of subject matter. But, if the teacher choosing this particular text sticks closely to it, one wonders just what concept the student would have of angiospermous groups and their relationships. As examples (and these are taken quite at random): The Cruciferae are treated, but nowhere is there any mention of the basic complex from which they seem to have been derived—the extensive, mostly tropical, and often arborescent Capparidaceae. The Aceraceae occupy several pages of text and a full plate of figures; but nowhere could I find mention of the much larger and more important Sapindaceae, their tropical precourser, except under the Fagaceae. The Asclepiadaceae apparently required two pages of figures; but the name Apocynaceae does not even appear as a word in the Index. In the Violaceae the genus *Viola* is taken as representative, together with the note that "a few tropical forms are shrubby"—with all omission of the fact that the basic, tropical members of the family are forest trees. We would fully agree that the Berberidaceae with their 150 species are worthy of inclusion; but one somehow misses certain families, such as the Myrtaceae with their more than 4,000 species, many of them of considerable economic importance, with others com-

monly grown as ornamentals in various parts of the United States. Obviously, not all the families of spermatophytes could be included in such a text, but it would seem that at least the larger and more important (even if mainly tropical) ones merit at least brief mention.

The foregoing is not so much intended as a criticism of this text as of all those which attempt a "general review" of the angiosperms on the basis of local, north temperate examples. By taking this viewpoint the beginning student in taxonomy unknowingly falls into a fundamental error—that of all too easily assuming that the plants which he finds on his brief field trips are representative of the families studied—or, for that matter, of the world's flora. This viewpoint, so far as leading to an understanding of the origin and development of the north temperate floras is concerned, is much akin to looking through the wrong end of a telescope.

This almost purely local viewpoint may also bring about another result. With so limited a concept of the background and ancestry of temperate groups—and finding these apparently adequately treated in the local manuals—the beginning student is prone to get the notion that there is little that remains to be done in taxonomy and so drifts into other fields. Actually, our taxonomic studies have scarcely more than scratched the surface of the majority of the great groups of plants. It would seem that this might well be one of the items which should be stressed in any textbook of systematic botany.—W. H. CAMP.

PROCEEDINGS OF THE CLUB

Minutes of the Meeting of April 16, 1947. The regular afternoon meeting of the Torrey Botanical Club was called to order by Dr. Jennie L. S. Simpson at 3: 35 p.m. in the Members' Room of the New York Botanical Garden. Sixteen members and friends were present. The minutes of the previous meeting were approved as read. No business was transacted and Dr. Simpson introduced Dr. A. B. Stout who spoke on "Data on the Heredity of One-way Hybridization." Following a discussion period the meeting was adjourned at 4: 45 p.m. Refreshments were served by members of the Garden staff.

Respectfully submitted,
LIBERO AJELLO,
Recording Secretary

Minutes of the Meeting of May 14, 1947. The regular evening meeting of the Torrey Botanical Club was called to order by the President Dr. George H. Shull, at 8: 30 p.m. at Hunter College. Thirty members and friends were present. The minutes of the previous meeting were approved as read. Four Associate Members and six Annual Members were elected.

No further business was transacted and Dr. Shull introduced Dr. Michael Evenari who spoke on "The Physiological-ecological Behavior of Desert Plants." This stimulating and highly informative talk was followed by a discussion period. The meeting adjourned at 9: 30 p.m.

Respectfully submitted,
LIBERO AJELLO,
Recording Secretary

Special Meeting of May 27, 1947. On this date the Torrey Botanical Club gathered in the Faculty Dining Room of Hunter College for a dinner meeting in honor of the retirement of three active members: Dr. B. O. Dodge, Dr. Arthur H. Graves, and Dr. Alfred Gundersen. The President, Dr. George H. Shull, presided and about 60 members and guests were seated.

After the dinner Dr. Shull called on Dr. W. H. Camp to introduce Dr. Gundersen. Dr. Gundersen told about his early interest in several sciences, and especially his interest in botany, while still living in Norway. After coming to this country his interest in plants became more pronounced and particularly his interest in classification. Several allusions were made to his new book which is in press. He urged the younger botanists, and especially teachers, to continue field work as one of the essential methods of really learning to know plants.

Next Dr. Shull called on Dr. John A. Small to introduce Dr. Graves. Dr. Graves made some additional complimentary remarks about Dr. Gundersen and his book. He also told of his own early interest in botany, and of his work in teaching the trees and shrubs course at the Brooklyn Botanic Garden. He was about to speak of his research, but noticing that his time was up he concluded his remarks immediately.

Finally Dr. H. A. Gleason was asked to introduce Dr. Dodge. Dr. Dodge told of his early connection, and that of Mrs. Dodge, with the Torrey Botanical Club. While he was a graduate student at Columbia University, they handled between them the work of the Secretary, Treasurer, and Bibliographer of the Club. After a sojourn in Washington, D. C., Dr. Dodge said he returned to the New York Botanical Garden on an agreement with Dr. Britton that he look after the plant diseases of the Garden, and the rest of the time he could devote to his own research. From that research has developed the genetics of *Neurospora*.

After the more formal part of the meeting, these three retiring members received congratulations from their many friends as the meeting broke up.

H.H.C.

FIELD TRIP REPORTS

JUNE 30, 1946. LAKEHURST, N. J. "It would have been impossible to have had a more perfect June day in the Pine Barrens. Temperature 55°, a brisk west wind, and no flies! The Bald Cypress was shown to the members at the start of the trip. The origin of the tree is in doubt. No rarities were found, but a number of the characteristic species of the Pine Barrens were located." A list was compiled of 32 plants seen in flower at this date. Attendance 3. Leader, David Fables.

AUGUST 25, 1946. BEACH HAVEN, N. J. A list of over 20 birds was compiled from observations on the mud flats at the southern tip of Long Beach Island and nearby Tuckerton Meadows. Sea Lavendar and Pink Sabattia were at the height of their bloom. Attendance 15. Leaders, David Fables and Charles Rogers.

NOVEMBER 3, 1946. POINT PLEASANT, N. J. "A heavy rain poured down all day but failed to dampen the enthusiasm of the members present. All were amply repaid for their efforts when 50 Gannets gave a very nice exhibition of diving for fish from heights of 10 to 50 feet above the surface of the ocean. An immature Jaeger was seen chasing a gull. The species seldom comes as close to shore as it did that day. 30 species of birds were observed." Attendance 15. Leader, David Fables.

MARCH 23, 1947. POINT PLEASANT, N. J. Although our Field Schedule was delayed in distribution until after this date, a group made the trip anyway and reported a successful study of waterfowl of the season. Plant life at the shore was still dormant but those plants usually observed in that aspect were found. Attendance 7. Leader, David Fables.

APRIL 13, 1947. NEW YORK BOTANICAL GARDEN. With the conservatories supplying the plant materials, a study of "Flowers of a Florida Garden and Their Stories" was offered. Our thanks to the Botanical Garden and their personnel for assistance. Attendance 8. Leader, Mrs. George Anderson.

APRIL 20. PLAINFIELD, N. J. A walk of 8 or 9 miles including valleys and ridges of the Watchung Mtns. A late spring is forecast by the small numbers of expected plants actually found in flower. Nevertheless, a good representation of the spring flora was seen

and a considerable variety of birds were recognized. Attendance 4. Leader, Dr. H. B. Gordon.

APRIL 20. NEW BRUNSWICK, N. J. A morning walk along the south bank of the Raritan River for collecting was followed by lunch and an afternoon of studying the material in the botanical laboratory of New Jersey College for Women. The following species of liverworts were found to have been collected: *Calypogeia trichomanis* (L.) Corda, *Cephalozia bicuspidata* (L.) Dum., *C. connivens* (Dicks.) Lindb., *Conocephalum conicum* (L.) Wiggers., *Gymnocolea inflata* (Huds.) Dum., *Odontoschisma prostratum* (Sw.) Trev., *Pellia epiphylla* (L.) Corda, and *Reboulia hemisphaerica* (L.) G. L. & N. Attendance 14. Leader, William Rissanen.

APRIL 27. PRINCETON, N. J. A walk along Stony Brook and through the associated woods. An extended list of early spring plants was compiled, the majority of the plants being in flower. Birds received the attention of several members of the group. An impromptu tour of the Princeton Campus was enjoyed by those willing to tramp the additional mileage. Attendance 20. Lealers, Peg and Charles Rogers.

MAY 4. WEST PARK, N. Y. "In spite of the terrible weather, we had 22 at the Slabsides trip today! We built a fire in John Burroughs' fireplace and dried off and listened to Julian Burroughs read some of his father's poems and tell stories of his childhood, as well as philosophize on Nature, on hawks that fly through his garage windows while the windows are closed, and on life in general. 'A good time was had by all,' was the general consensus." Leaders, Farida A. Wiley and Harold N. Moldenke.

MAY 4. ALLAIRE, N. J. The Dutchman's breeches were there but nearly inundated, as were the five participants. Leader, Mr. V. L. Frazee.

MAY 4. WATCHUNG RESERVATION, UNION COUNTY, N. J. Two early bird walks; five late morning walks for ecology, trees, minerals, mosses, and other plants; a fine display in the museum; and a talk by the Naturalist from Trailside Museum at Bear Mtn. opened the nature study program and the museum in the usually impressive manner. Attendance was about 30 water resistant nature lovers plus uncounted visitors after the sun came out. Leader, Mildred Rulison and assistants.

MAY 10–11. PALISADES INTERSTATE PARK, N. Y. A pleasant weekend with congenial folks at Camp Thendara. Bird study and spring flowers were enjoyed by invitation of the New York Section of the Green Mountain Club. Attendance 28. Leader, Mrs. Laura W. Abbott.

MAY 11. GREENBROOK SANCTUARY OF THE PALISADES. There was a good response to the appeal for aid in the biological survey of this sanctuary. A general survey was made and a start on listing the species in the various groups. The further participation of local botanists is urged. Attendance 19. Leaders, Mrs. F. G. Dunham and G. G. Nearing.

MAY 16–18. BRANCHVILLE NATURE CONFERENCE, CULVERS LAKE, N. J. The full program of activities announced in the "Field Schedule" was carried out. Reports made at the closing meal indicated that a good deal had been accomplished in the field and indoors. Our hearty thanks to everyone. There were only about half the usual number present and a program geared for 100 does not work out satisfactorily with little more than half that number. The question of whether this Conference has now served its usefulness and should be discontinued is now under consideration. Anyone having ideas on the subject should report to the Chairman of the Field Committee. Attendance 61. Leaders, Messrs. James Hawley, Wallace Husk, and instructors announced.

MAY 17. CHEESEQUAKE STATE PARK, N. J. This trip initiated a collection of the hepatics to be found in the Park. Eight species were recorded and will be included in the more comprehensive report on the area. In addition, eight new birds were added to the list for Cheesequake. Attendance 5. Leaders, Louis Hand and William Rissanen.

MAY 17. CEDAR BROOK PARK, N. J. Our leader, who is Horticultural Chairman of the Plainfield Garden Club, has been remarkably successful in working up the cooperation of

other clubs and of the Union County Park Commission to the point where several plantings have been made in this park. They have all had competent supervision and really good care, considering the conditions of recent years. We were embarrassed about the attendance but our appreciation was the greater. Attendance 3. Leader Miss H. R. Halloway.

MAY 25. AUDUBON NATURE CENTER AND FAIRCHILD WILD FLOWER GARDEN, GREENWICH, CONN. Those participating made good use of their check lists for birds and saw many plants of interest. It was nice to meet the new director, Charles Mohr, already known to some of us by his fine work at the Academy of Natural Sciences of Philadelphia. Attendance 15. Leader, Mrs. Henrietta Dotson.

JUNE 7. ATLANTIC BEACH, LONG ISLAND. A joint outing with the Department of Natural History of Brooklyn Institute. A killdeer's nest and live oysters were seen. Sea anemones and some species of land snails were recorded for the first time here. A beginning of the mud flat succession was observed, a miniature salt marsh having appeared on a low area previously held exclusively by *Salicornia*. Attendance 14. Leader, Grace Petersen.

JUNE 9–12. SOUTHEASTERN KENTUCKY. Thirty people assembled at the Mountain Preachers' School at Clear Creek Springs on Monday, June 9. Dr. Lucy Braun gave an illustrated lecture that evening setting the plan of the three days to follow. Tuesday was spent seeing the Mixed Mesophytic Forest at two elevations on Log Mtn. in the morning. After lunch the Hemlock Garden and two other stands on Pine Mtn. were visited, the last at a fire tower, afforded an excellent opportunity to see the geological setting in which the various plant communities had developed. The stands of virgin timber of many species, great height, and enormous basal size were most impressive. Tulip tree, magnolias, and flame azalea added the beauty of their flowers, as did many of the ground plants.

Wednesday provided a 200-mile drive with carefully documented itinerary so that all points of interest to the group could be seen without driving in close formation. This route led up the Cumberland valley, over Pine Mtn., through the hill country of the Cumberland Plateau, to the cliff region of the Red River at Natural Bridge, Ky., where Hemlock Lodge provided us excellent accommodations. Thursday was devoted to the forests of the cliff region and Red River valley. These ranged from pine forests reminiscent of New Jersey (We even saw *Pogonia divaricata*, as rare in Kentucky as in N. J.) to various well developed aspects of the Mixed Mesophytic Forest. The last stop was a fitting climax for around an undercut cliff formation known as a "stone house" we saw filmy fern and a co-type locality for *Solidago albapilosa* Braun. Leader, Professor Lucy E. Braun, University of Cincinnati.

Local Flora Committee. At the May meeting of the Council, the Chairman of the Field Committee was also made Chairman of the Local Flora Committee of the Club. It is planned to continue the joint chairmanship at least pending a decision as to the province of each committee and the possible desirability of combining the two. The Field Committee has probably overlapped the Local Flora Committee somewhat in its activities. Members who wish to suggest projects for either committee, or who desire changes in their activities are urged to communicate with the Chairman, John A. Small, N. J. College for Women, New Brunswick, N. J.

INDEX TO AMERICAN BOTANICAL LITERATURE

COMPILED BY

LAZELLA SCHWARTEN

WITH THE COLLABORATION OF THE EDITOR OF THE TAXONOMIC INDEX

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(including Anatomy & Cytology in part)

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